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A Summary of Current Program as of October 1, 1963
and Preliminary Report of Progress
for October 1, 1962 to September 30, 1963

MARKET QUALITY
RESEARCH DIVISION
of the

AGRICULTURAL MARKETING SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

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This progress report is primarily a research tool for use of Department scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs. The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This progress report was compiled in the Market Quality Research Division, Agricultural Marketing Service, U. S. Department of Agriculture. It also includes a list of publications reporting results of Department and cooperative research in the field of work of this division, issued between October 1, 1962 and September 30, 1963. Current marketing research findings are also published from time to time in the monthly AMS publication, "Agricultural Marketing."

UNITED STATES DEPARTMENT OF AGRICULTURE
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INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of food and fiber, and the development of new methods and devices for the physical and biological evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Marketing Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at the Plant Industry Station, Beltsville, Maryland. Here the Instrumentation Research Laboratory, the Post-harvest Pioneering Research Laboratory, and field stations of the Field Crops and Animal Products Branch, and the Horticultural Crops Branch are located. There are also 18 field stations located throughout the country including 2 Terminal Market Laboratories. Division personnel are also located at 5 State Experiment Stations. Total research effort including research contracts amounts to approximately 165 professional man years.

The importance of research on quality protection and measurement and the need for it is demonstrated repeatedly by the heavy losses which occur in the storage, transport, and distribution of food and fiber, as a result of insect attack, microbiological spoilage, physiological deterioration, or some other cause. The dissatisfaction with the quality of commodities as purchased and the tedious methods required in grading and inspection are clear evidence that we need better methods and equipment for quality measurement, grading and classing.

As might be expected an appreciable amount of Market Quality research is related to the effective performance of the Service Divisions of the Agricultural Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. The Division also works closely with industry and other Government Agencies on various problems relating to Agricultural commodities in the marketing channels. Specific examples of Market Quality research accomplishments over the past 5 years are:

Quality Maintenance of Export Grain with Insect Protectant. The State Department's Agency for International Development reports that the malathion grain protective treatment, developed by SPI, and the proper spraying of the ships holds during the past year have practically eliminated complaints from abroad that whole grains exported under P. L. 480 programs arrive at their destination infested with weevils. The malathion treatment, applied to the grain just prior to or during loading, protects the grain against insect infestation during shipment, as well as for several months after it reaches its destination.

Rapid Accurate Moisture Determination of Grain. A new method for measuring the moisture content of grain has been developed. A direct spectrophotometric measurement is made on a ground sample to indicate the moisture content to a precision of 0.1%. This is a fundamental method of measurement which may serve as a definition of moisture content. Technique has been applied only to wheat, wheat flour and soybeans, but it should be applicable to all grains and seeds.

The Influence of Bovine Age on Meat Characteristics and Grade. The basic study conducted by Oklahoma State University under an AMS contract provided valuable information to evaluate present grade standards for reflecting the effect of age upon meat palatability. It was found that tenderness of the longissimus dorsi steaks as measured by the Warner-Bratzler Shear and panel (with marbling of each carcass at or closely approaching either the "slight amount" or "slightly abundant" level) decreased significantly with increasing animal age. The greatest difference in tenderness was observed between the 18- and 42-month age groups. The effect of aging the meat 14 days varied with animal age, marbling level, and the tenderness measure used. Moisture, ash, and protein contents of loins were not significantly different for the age groups except that the 6-month-old calves had slightly higher moisture values.

Improved Effectiveness of Commercial Vacuum Cooling of Lettuce. In the major producing areas lettuce has been precooled by the vacuum process for more than 10 years. During some of this time research was underway by AMS in a pilot vacuum cooling plant at the Fresno, California, field laboratory. These studies indicated that the full potential of the process was not being obtained in commercial plants.

More recently a detailed study was made in several commercial plants to relate findings in the pilot plant to industry practice. Such factors as rate of air exhaust, final tank pressure, surface temperature of the condenser, total exposure to effective vacuum, and wet bulb readings were related to final leaf and core temperatures. As a result of these studies some cooler operators have modified procedures and refined instrumentation with the result that final lettuce temperatures of 33° to 35° F. are obtained as compared with the 36° to 40° temperatures before modifications. This temperature difference is critical for the control of soft rot and russet spotting in this highly perishable vegetable.

Ethylene Dibromide Fumigant Affects Egg Laying. Although ethylene dibromide has been used for many years as a fumigant for food and feed grains, it was only in the last few years that poultry farmers suspected that it affected egg laying. Research under an AMS contract at the University of Georgia has now shown that about 5 p.p.m. of ethylene dibromide in the feed of hens definitely reduces the size of eggs. The rate of egg production was not affected by 40 p.p.m., but 80 p.p.m. caused a significant drop, and 160 p.p.m. stopped production completely within 7 weeks. As a result of these studies, the grain and poultry industries are being cautioned against the use of ethylene dibromide for treating grain destined for poultry feed.

Nondestructive Measurement of Interior Quality of Fruits, Vegetables and other Commodities. Techniques and equipment have been developed for making measurements of the spectrum of light transmitted through intact fruits and vegetables. These measurements have led to the development of methods to measure the maturity of peaches, apples, plums, and other fruits, to detect black-spot of potatoes, water core or other internal disorders of apples, and blood spots in eggs. Methods can be made available whereby the non-conforming specimens are automatically removed from the packaging lines.

These examples of research accomplishments illustrate the variety of work engaged in and its potential value in prevention of damage to the commodity and loss of quality. The savings made by this kind of research, benefiting both the consumer and the producer, amounts to many millions of dollars each year. The year-round supply of a great variety of wholesome, nutritious food, some of it extremely perishable, is tangible evidence of the progress in the handling, transportation and storage of food. The research of the U. S. Department of Agriculture in this field over the past 50 years has made a major contribution to the practices now in use in the marketing of agricultural commodities.

AREA 1

CITRUS AND SUBTROPICAL FRUIT - MARKET QUALITY

Problem. Research is needed on the measurement of quality in citrus and other subtropical fruits. With a better understanding of quality characteristics and objective indices for the measurement of quality, grades and standards would be more meaningful and could be better enforced. In addition instrumentation for quality measurement lends itself to ultimate automatic devices for quality sorting on a commercial basis. Fruit soilage and wastage resulting from postharvest decays of citrus fruits present serious problems in both domestic and export markets. Much research is needed to relate handling practices, packaging, precooling and transit refrigeration to decay and soilage, and to develop and evaluate physical and chemical treatments for decay reduction. Research is also needed on the storage of citrus fruits. Optimum storage temperatures for the principal varieties of oranges produced in different areas need further investigation. There is also a vast field for research on controlled atmosphere storage for oranges, grapefruit and lemons. Problems exist in each of the geographical areas which are sometimes distinct and sometimes interrelated, but which require biological research in the separate production areas for solution. Several species of common stored-product insects attack dried citrus pulp animal feed and may build up tremendous populations. In some cases wholesalers and retailers have refused to handle the product because the excessive insect infestation creates a hazard to other commodities in stock. There is an urgent need for effective preventive measures to be used in warehouses that will not leave hazardous residues in the feed, and for the development of packaging that will resist insect infestation of the product in marketing channels.

USDA PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. The work is conducted in the producing areas of California, Florida and Texas. Market studies are made in New York City and Chicago. P.L. 480 grants are operative for research in Columbia on chemical and physiological variables in avocado and papaya fruits during ripening; for studies in India on identification and mode of infection of fungi causing postharvest rots in seven species of tropical fruits; a project in Italy on X-ray detection and identification of incipient decays in citrus fruits; and a recently negotiated contract in Spain on detection of additives

in citrus juices. A study on objective measurement of maturity is conducted, under contract, by the California Agricultural Experiment Station at Riverside. Research on biphenyl for decay control is done in cooperation with the California Citrus Research Committee. Current irradiation research is done in part with funds provided by the Atomic Energy Commission.

Total federal professional man-years devoted to this area is 11.1. Of this 3.0 is devoted to objective measurement of quality; 0.6 to quality maintenance in storage; 2.0 to quality maintenance during transportation; 1.0 to postharvest physiology; 4.0 to postharvest disease control; and 0.5 to program leadership. P.L. 480 projects in this area involve \$64,145 equivalent over a 3-year period in Columbia; \$45,200 equivalent over a 5-year period in Italy; \$29,732 over a 5-year period in India; and \$56,163 equivalent over a 4-year period in Spain.

Work terminated during this period included transit protection of Hawaiian fruits (MQ 2-25); biphenyl resistance of Penicillium sps. (MQ 2-26); transportation of California citrus (MQ 2-27); accumulation of biphenyl in citrus fruits (MQ 2-28); enzyme activity related to maturity of avocados (part of MQ 2-46); and enzyme activity and maturity of avocados (part of MQ 2-60).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Relation of Physical Properties, Chemical Composition and Metabolic Activity to Market Quality of Citrus. Weight, volume, length, and diameter measurements of Florida-grown Marsh grapefruit showed decreases during storage in each of seven tests. This shrinkage proceeded only slightly more rapidly at 60° than 32° F. Ethylene treatment markedly increased the rate of shrinkage during the treatment period, but the rate in subsequent storage was frequently lower. Seasonal changes, though possibly influenced by the freeze, show an increased amount of shrinkage with increased maturity.

Results of three tests on oranges indicate that the same pattern of response occurred, but the changes were proportionately greater than on grapefruit.

A test with a commercial reflectance sorter indicates that satisfactory sorting of oranges for color can be made by this means.

Basic studies being conducted under contract with the University of California, Riverside, have continued. Data on labeled carbon dioxide fixation and exchange in orange tissues indicate a significant

drop in rate of C¹⁴ O₂ fixation in the vesicles as maturation progresses.

Experiments with specifically labeled glucose showed significant differences between tissues in probable major metabolic pathways. In all tissues carbon 1 of glucose is catabolized more rapidly than either carbon 2 or carbon 6. However, whereas carbon 2 is metabolized more rapidly than carbon 6 in flavedo, the opposite is true in albedo and vesicles. There may be a significant change during maturation in the rate of catabolism of carbons 3 and 4 of glucose relative to other carbons. (MQ 3-20)

2. Aromatic Polynuclear Hydrocarbons in Horticultural Crops. Work is underway at the Pomona, California laboratory to develop methods for removing polynuclear aromatic hydrocarbons from the surface of citrus fruit, for subsequent qualitative and quantitative analysis. The most promising procedure at present for measuring these hydrocarbons is to extract them with n-pentane, separate them by thin layer chromatography, elute the desired portions, and determine absorbence on a U. V. spectrophotometer. (MQ 3-46)

3. Enzyme Activity and Maturity of Avocados. A preliminary study at Beltsville showed no detectable change in pectinmethyl esterase activity that could be associated with maturity of avocados. No further work is planned. (MQ 2-46)

B. Quality maintenance in storage

1. Ripening and Storage of Florida Mangos and Avocados. Storage studies on a new and important mango variety, Tommy Atkins, indicate that it has excellent storage characteristics and shelf life. The fruit softened in 3 weeks at 70° F. and no chilling injury was detected after 1 week at 45°. Tommy Atkins is one of the firmest and brightest and most attractive of the commercial varieties; eating quality is only fair.

Studies on a new variety of avocado, Ruehle, indicate that it has typical characteristics of the West Indian strain, particularly in susceptibility to chilling injury at temperatures below 50° F. (MQ 2-46)

C. Quality maintenance during transportation

1. Export Shipment of Florida Grapefruit. This work has shown that early season, minimum maturity, Marsh Seedless and Ruby Red grapefruit should be transported at 60° F. to avoid rind breakdown during distribution in European markets. Fifty to 55° F. is a better temperature for the more mature fruit. The simulated export studies conducted this season substantiated the findings of the previous crop year.

Some of the more promising pretransit treatments and simulated transit temperatures were applied in a test shipment originated October 27, 1962 with white and red-fleshed grapefruit transported from Tampa, Florida, to Hamburg, Germany.

In this shipment, a uniform fruit temperature of 60° F. was attained after 2 days in the refrigerated hold and this was maintained throughout the transit period. The fruit temperatures in the ventilated hold were about 70° F. for the first 7 to 8 days and then gradually decreased to 45° F. The relative humidity ranged from 74 to 89 percent in the refrigerated hold and 55 to 95 percent in the ventilated hold. A slight build-up of carbon dioxide was noted in the refrigerated hold.

No rind breakdown developed in any of the test fruit during transit or during the 2-week holding period at 60°. Decay on arrival was 2 percent or less and 6 percent or less after 2 weeks' holding at destination. The rind of the washed-only (not waxed) fruit shipped under refrigeration and ventilation changed from green to an acceptable yellow color during transit. However, this unwaxed fruit shipped in ventilated stowage developed excessive shrivel.

A "containerized citrus export test" was conducted in cooperation with the Transportation & Facilities Research Division. Test grapefruit developed less than 1 percent decay upon arrival and only 3 percent after 1 additional week at 60° F. (MQ 2-74)

2. Thermal Conductivity of Florida Citrus Fruit. Thermal conductivity values were determined for the rind and juice vesicles of Valencia oranges and Marsh Seedless grapefruit. The thermal conductivity values of the Valencia rind ranged from 1.0886 to 1.3394 BTU/hr/ft²/°F/in. and of the juice vesicles from 2.7968 to 3.3430 BTU/hr/ft²/°F/in. The thermal conductivity of the rind of the Marsh Seedless grapefruit ranged from 1.4091 to 1.8005 BTU/hr/ft²/°F/in. and from 2.8523 to 3.4875 BTU/hr/ft²/°F/in. for the juice vesicles. (MQ 2-53)

3. Maintaining Quality of California Citrus in Transit. A test in California with the single-bunker, thermostatically-controlled, ice-refrigerated rail car revealed inadequate air movement through a chimney load of citrus fruit in cartons even though the air was ducted past the doorway. However, continuous operation of the fans in the single-bunker car cooled the fruit more than a conventional car with intermittent fan operation. At the end of a 36-hour precooling period the average fruit temperature was lowered 6 degrees more in the single-bunker than in the conventional car. This work has been completed. (MQ 2-27)

4. Effect of High Nitrogen - Low Oxygen Atmosphere on Bananas.

Tests were continued comparing the effects of atmospheres of 99% and 100% nitrogen, and air, on ripening, decay and firmness of green bananas. Bananas held in air at 60° F. for 7 days ripened completely in 3 days after being removed to air at 70°. Bananas subjected to 99% nitrogen for 7 days at 60° required 8 days after removal to air at 70° to ripen completely. When treated in 100% nitrogen, bananas failed to ripen when removed to air at 70°. Following treatment and 6 days' holding in air at 70°, check (air-stored) fruit had almost twice as much decay as those treated in atmospheres of 99% or 100% nitrogen. Firmness was highest at every inspection in those bananas treated in atmospheres of 99% or 100% nitrogen. (MQ 2-71)

D. Postharvest physiology

1. Respiration of Florida Citrus Fruits in Relation to Postharvest Rind Breakdown. Brushing increased the rate of respiration of oranges. The increase in rate of respiration and in rind breakdown as a result of brushing was greater in the Pineapple variety than in the Valencias. Respiration rate and amount of rind breakdown increased as delay between time of harvest and time of brushing increased.

Hot water treatment of Valencia oranges increased the respiration rate and increased rind breakdown to about the same extent as did brushing.

Brushing and hot water treatments caused fruits to lose more weight than untreated fruit while, as expected, waxing decreased weight loss.

Waxing with commercial solvent waxes, either with or without sodium orthophenylphenol, had no apparent effect on respiration rates. (MQ 2-79)

2. Postharvest Changes in Avocados and Papayas. Research under a P.L. 480 project in Columbia with avocados, primarily of the West Indian strain, shows 70° F. to be an excellent ripening temperature. Chilling injury often occurred at 50°. Fruits with highest oil content had the most resistance to chilling injury. Some moisture and oil determinations were made, but are inconclusive.

Papayas had best quality when ripened immediately at 65° F. They remained in good condition for 14 days at 50° but flavor deteriorated. Heat treatment for 20 minutes at 120° reduced decay and did not affect flavor or keeping quality. Fruits with some excess of sucrose over reducing sugars had the best flavor. (S5-AMS-3)

E. Postharvest disease control

1. The Incidence and Nature of Biphenyl Resistance in Lines of *Penicillium Digitatum* and its Effects on Decay in Citrus Fruits.

Biphenyl content was determined for biphenyl-tolerant and biphenyl-sensitive clones of *Penicillium digitatum* cultured in atmospheres containing biphenyl vapors. In these investigations conducted in California the biphenyl-tolerant and biphenyl-sensitive cultures both contained approximately the same amount of biphenyl. Whether the biphenyl was adsorbed onto the fungus mycelial strands or absorbed into the protoplasm of the fungus cells was not determined. The answer to this question for both biphenyl-tolerant and biphenyl-sensitive strains of *penicillium* should be basic to further investigations of mode of action of biphenyl, and help explain the nature of tolerance in *Penicillium* strains. (MQ 2-26)

2. Chemical and Non-chemical Control of Decay of California Citrus Fruits.

Green mold of lemons was as effectively controlled by immersion of the fruit in hot water as by several standard and experimental chemical treatments. Immersion of inoculated lemons in water ranging from 110° F. for 10 minutes up to 130° for 10 minutes or 135° for 1 minute gave good control of green mold rot. Severe rind damage occurred soon after lemons were treated at 135° for 10 minutes. Mild damage occurred after several weeks' storage, on lemons treated at 135° for 5 minutes, and slight damage after a longer period on lemons treated at 130° for 10 minutes. (MQ 2-24)

3. Control of Postharvest Diseases of Florida Citrus Fruit.

Secondary-butylamine evaluated as a decay inhibitor for the second season in Florida, gave good results when used as a 1-percent dip and when incorporated in a wax emulsion. However, it was not consistently better than sodium-o-phenylphenate (SOPP), as now used commercially.

Hot water treatment for control of decay was further investigated for oranges and grapefruit. From 50 to 75 percent reduction of stem-end rot and green mold was obtained. The most effective temperature for immersion treatment was 127° F. for 5 minutes. A water temperature of 132° was required to give the same results when the fruit was flood treated. Decay control was increased by delaying treatment for 1 to 3 days following picking. However, rind breakdown of oranges was increased by this delay. Rind breakdown attributable to hot water treatment was not usually observed on grapefruit. Fruit which had been treated with hot water appeared to be more susceptible to reinfection or subsequent infection by *Penicillium* than did non-treated fruit.

Observations made on oranges harvested at weekly intervals before and after the freeze of December 12, 1962, revealed that minimum field temperatures of 20° to 22° F. had little effect on stem-end rot

development, but green mold was substantially increased after the freeze.

Ninety-four isolations of Phomopsis citri and 80 isolations of Diplodia natalensis were made from stem-end rotted fruit collected throughout Central Florida. These were tested in culture for reaction to biphenyl and SOPP. The Phomopsis isolates were relatively uniform in their growth habits and response to both chemicals. The Diplodia isolates were more variable ranging from complete sensitivity to moderate resistance. None were highly resistant nor immune. (MQ 2-65)

4. Irradiation for Control of Postharvest Diseases. Radiation induced monoauxotrophic, haploid, white, avirulent mutants of P. italicum were used for the preparation of weakly virulent heterocaryons. On minimal media, diploid, blue green, extremely virulent sectors were recovered. Haploid segregants from the diploid consisted of parental and recombinant types. Recombination resulting in prototrophy restored virulence. No gene linkage was detected between color and nutritional requirements. This is the first time a parasexual cycle has been reported for P. italicum and gives a rational basis for the introduction of new strains in this asexual fungus (conidial form).

Sixty-five color mutants of irradiated P. italicum and P. digitatum conidia (normally blue green and green) were classified into color groups. In general, virulence or avirulence could not be associated with a particular color phenotype. Approximately 44% of the color mutants of P. italicum and 67% of the P. digitatum mutants were virulent.

P. italicum and P. digitatum yielded 53 and 21 auxotrophic mutants respectively. Among the exogenous requirements for growth were: vitamin growth factors, purine and pyrimidine bases and amino acids such as adenine, methionine, cysteine, proline, lysine, inositol, pantothenic acid, nicotinic acid, biotin and choline.

The pectolytic enzymes of P. italicum and P. digitatum such as polygalacturonase (PG) and cellulase (Cx) have been demonstrated both in vivo and in vitro. Only virulent mutants produce PG and Cx in the orange while avirulent mutants produce only Cx.

Radiation induced mutants of A. fumigatus were not different from naturally occurring mutants in resistance to several chemicals. (MQ 2-32)

5. Control of Anthracnose on Mangos. Hot water treatments by immersion applied after harvest to five commercial varieties of Florida mango fruits (Zill, Haden, Sensation, Kent, and Keitt) showed

considerable promise as a control for anthracnose. The most effective hot water treatments involved exposures of about 5 minutes in water at 130 to 132.5° F. Fruit was damaged by treatments of longer duration and at higher temperatures. Treatments at 125° required 15 minutes exposure to reduce decay effectively. The different varieties of mangos varied in their susceptibility to damage from heat treatments. Flavor and natural ripening were not impaired by heat treatment. (MQ 2-68)

6. Stylar-end Breakdown of Limes. Stylar-end breakdown was increased by handling incident to harvesting, sorting and packing. After storage for 21 days at 50° F. less than 4 percent of the limes obtained directly from the tree had stylar-end breakdown. Samples of fruit obtained from field boxes at the packinghouse had 9 percent of the disorder. In another test, fruit were intentionally bruised on the stylar end and stored for 21 days at 50° F. An average of 27% of the bruised limes were affected with stylar-end breakdown; only 6% of the non-bruised limes were affected.

Grove source was directly related to the extent of stylar-end breakdown. Of the total number of limes developing stylar-end breakdown during storage, 33% developed the disorder within 3 days after harvest and 75% developed it within 7 days.

Later in the harvest season when stylar-end breakdown was not prevalent, handling or intentional bruising of limes had no apparent effect on the extent of stylar-end breakdown. (MQ 2-40)

7. Postharvest Diseases of Tropical Fruits. Under a P.L. 480 project in India a study is underway on the microorganisms which cause postharvest decay in mangos, guavas, bananas, sapodillas, litchis, papayas and pomegranates. This includes a comprehensive survey of the pathogens causing rots and the source of the inoculum. Several organisms which infect leaves and stems have been shown to also cause postharvest infections in fruit. Some organisms not previously reported as pathogenic have been shown to cause fruit rots. The carbohydrate substrates used by some organisms have been identified. (A7-AMS-6(k))

8. X-ray Detection and Identification of Incipient Infections. Studies with X-ray techniques for studying fruit infections are underway in Italy under a P.L. 480 project. The study has not progressed beyond rather gross studies of internal structure and a preliminary study of the course of infection by Penicillium glaucum. No evidence has yet been developed to indicate that X-ray techniques are useful for this purpose. (E15-AMS-4)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Storage.

Chace, W. G., Jr., and Harding, P. L. 1962. Storage Requirements for Pope's Summer Orange. Proc. Fla. State Hort. Soc., Vol. 75, pp. 326-331. (MQ 2-51)

Quality Maintenance During Transportation.

Akamine, E. K., Shoji, K., Nakamura, M., Watanabe, H., Higoki, T., Cooil, B. J., Rygg, G. L., and Wells, A. W. 1963. Studies on Temperature, Humidity, and Other Factors During Handling and Transit as Factors Affecting Quality and Marketability of Papayas. Unnumbered Mimeo. Hawaiian Agricultural Experiment Station. (MQ 2-25)

Chace, W. G., Jr., Harding, P. L., and Cubbedge, R. H. 1963. An October Shipment of Florida Grapefruit from Tampa to Hamburg. Citrus and Vegetable Magazine, pp. 26-28. (MQ 2-74)

Hatton, T. T., Jr., Chace, W. G., Jr., and Harding, P. L. 1962. An April Test Shipment of Florida Grapefruit from Tampa to Hamburg. Citrus and Vegetable Magazine, pp. 26-28. (MQ 2-74)

Johnson, H. B. 1963. Truck-rail and Sea-land Shipping Tests with Texas Fruits and Vegetables. Marketing Research Report No. 589. (BS 2-165)

Postharvest Physiology.

Davis, P. L., Harding, P. L., and Sunday, M. B. 1963. Factors Affecting Rind Breakdown of Citrus Fruit. Marketing Research Report No. 596. (MQ 2-1)

Scholz, E. W., Johnson, H. B., and Buford, W. R. 1963. Heat Evolution Rates of Some Texas-Grown Fruits and Vegetables. Jour. of the Rio Grande Valley Hort. Soc., Vol. 17, pp. 170-175. (BS 2-141)

Postharvest Disease Control.

Rygg, G. L., Wells, A. W., Norman, S. M., and Atrops, E. P. 1962. Biphenyl Control of Lemon Spoilage. Influence of Time, Temperature, and Carton Venting. Marketing Research Report No. 569. (MQ 2-28)

- Smoot, J. J., and Segall, R. H. 1963. Hot Water as a Postharvest Control of Mango Anthracnose. Plant Disease Reporter, Vol. 47, pp. 739-742. (MQ 2-68)
- Wells, A. W., Norman, S. M., and Atrops, E. P. 1963. Measurement of Biphenyl Vapor. Jour. of Gas Chromatography 1(9):19-20. (MQ 2-28)

AREA 2

DAIRY PRODUCTS - MARKET QUALITY

Problem.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage life of dairy products. Several kinds of stored-product insects and mites damage or contaminate dairy products and cause extensive losses, principally in nonfat dry milk and cheese. The losses are important not only to the dairy industry but also to the Department in connection with its price support and storage program. To maintain quality of these products in marketing channels, research is urgently needed on the factors influencing keeping quality, and on the development of safe and effective procedures for controlling and/or preventing infestation in warehouse storage, and during transportation by rail, as well as by packaging to provide better protection for nonfat dry milk against infestation. New and improved objective quality tests are also needed for bulk milk and other products. A related problem is the occasional presence of antibiotic and pesticide residues for which improved detection methods are needed.

USDA PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. Work is being done at Beltsville, Maryland, on the development of simple, rapid screening tests for detection of chlorinated insecticide residues in dairy products and on the stability of anhydrous butterfat in storage. A 2-year contract study with the University of California at Davis on the estimation of protein content of milk by dye-binding is nearing completion. A 3-year contract with the University of Minnesota was initiated during the past year to study the quality of milk used for manufacturing purposes. The Federal scientific effort devoted to research in this area, objective measurement and evaluation of quality, totals approximately 2.0 professional man-years.

Study of the types of bacteria responsible for the deterioration of market milk (E8-AMS-2(a)) was terminated during the period.

There is a long-term program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation and contamination of dairy products in the marketing channels. Cooperative work with the Wisconsin Agricultural Experiment Station, the Commodity Credit Corporation, and industry groups is included. In addition to work specifically aimed at insects attacking dairy products, previously done at Madison, Wisconsin, studies applicable to these and other insects as well are conducted at Savannah, Georgia, and are reported in Area 13, "Insect Control in Marketing Channels."

The Federal scientific effort in the insect studies totals 2.0 professional man-years divided as follows: basic biology and ecology 0.6; insecticide evaluation 0.5; insecticide residues 0.1; insect-resistant packaging 0.6; and program leadership 0.2.

Toward the end of the reporting period the work at Madison was relocated at the stored-product insects station at Fresno, California, as part of a Branch action to consolidate several small field stations. This will permit more effective utilization of manpower and equipment.

Line project MQ 1-4, dealing with the control of dermestid beetles in dry-milk processing plants, was terminated with completion of the major objectives of the project.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Pesticide Residues. Work was completed on the development of two chromatographic techniques for separation of pesticide residues from fats and other interfering materials (cleanup) using, respectively, carbon-celite, and Florisil. By use of these chromatographic techniques, the sample can be prepared for analysis by paper chromatography in one step where formerly two or more steps were required. Nearly all common chlorinated insecticides can be separated from interfering materials by these procedures so that a reasonably complete screening of samples for pesticide residues can be made in one operation. The Florisil cleanup is especially

useful for samples containing butterfat. Carbon-celite cleanup can be used in a few cases for insecticides in butterfat which cannot be recovered from Florisil, but it is more satisfactory with other agricultural products. The use of the chromatographic procedures for cleanup of samples for colorimetric determination of DDT was also studied but a number of problems in the overall procedure were encountered and these are still under study.

(MQ 3-11)

2. Protein Content. This study on the estimation of the protein content of milk by dye-binding is being carried out under contract with the University of California at Davis. Amido black was selected as the most satisfactory dye for this purpose. It is available commercially in a form relatively free from interfering materials, it gives a greater change in optical density per unit of protein and the dye-protein complex can be removed by centrifugation. The dye-protein reaction was studied in detail. The relation of protein to dye bound by protein was non-linear. This may also be the case with samples of mixed herd milk collected in the field. Mastitic milk differed significantly from normal milk in dye-binding capacity.

(MQ 3-14(c))

3. A Study of Methods for Grading Milk. A survey of the quality of milk for manufacturing was initiated under contract with the University of Minnesota. Samples of both can and bulk handling are being collected during all four seasons from three major producing areas, Iowa-Minnesota-Wisconsin; Missouri-Kentucky-Tennessee; and the Boise Valley in Idaho. Bacteriological quality will be evaluated from plate counts and reduction tests which will be related as far as possible to farm practices in order to provide a basis for setting up grading standards. Spring and summer sampling has been completed for Iowa-Minnesota-Wisconsin and summer sampling for Missouri-Kentucky-Tennessee. No analysis has been made of data obtained thus far.

(MQ 3-44)

4. Bacteria in Market Milk. The final report on this project was received during the reporting period. The study was concerned with the types of psychrotrophic bacteria found in market milk. A "key" method was developed using a computer to sort bacterial isolates into nine groups on the basis of a limited number of tests. Pseudomonads were found to be of major importance in spoilage of milk at refrigerator temperatures. Alcaligenes species and

enterobacteria were also involved. Rapid spoilage was associated with the simultaneous development of several strains of bacteria and slow spoilage occurred when one or rarely two strains of bacteria gained dominance. In the former case, flavor defects were poorly defined, but under the latter evaluations, one or two specific flavor defects developed after relatively long storage time.

The results obtained in this study provide a theoretical basis for predicting keeping quality of market milk. However, no practicable method of applying this information to routine testing is yet available.

(E8-AMS-2(a))

B. Prevention of insect infestation

1. Basic Biology and Ecology. A significant discovery is that insects infected with a pathogen fluoresce a bright yellow-green when irradiated with ultraviolet light in the 366 m μ band. The phenomenon has been demonstrated with Trogoderma glabrum, T. inclusum, and the Indian-meal moth. The infective organism has been identified as the Schizogregarine protozoan, Mattesia dispora Naville. Using a Beckman DK-2 recording spectrophotometer, it was determined that the emission spectrum of an aqueous suspension of the spore stage of the protozoan was 512.3 m μ with a 363 m μ source lamp. This discovery provides a useful tool in the study of the disease and in its control in laboratory cultures. It should stimulate interest in biological control studies with this highly pathogenic organism. A technique was developed for obtaining Trogoderma larvae free of the disease. Eggs obtained by using a special oviposition chamber are sterilized with mercuric chloride and alcohol, then transferred to sterile jars and rearing medium.

(MQ 1-4)

Further studies have been made with the sex attractant produced by unmated adult females of the black carpet beetle and two species of Trogoderma, glabrum, and inclusum. Adult males have been found to respond to this attractant in a characteristic pattern. The characteristic features of response are a forward and upward extension of the antennae, a zigzag pattern of movement, and elevation of the fore part of the body. Evidence was obtained that the receptors are in the male antennae. The attractant has been collected on absorbent paper discs over which unmated females have walked, by an ether wash of filter paper and glass jars that have held the

females, or by filtering it from an air stream passed through a flask containing the females. A simplified method has been developed for collecting the attractant on absorbent paper discs, and for handling and bio-assaying the discs.

(MQ 1-32)

2. Insecticide Evaluation. Laboratory studies showed that all black carpet beetle larvae were killed after a 7-day continuous exposure on a malathion residue that had aged 4 weeks after application over a special floor finish or a traffic paint that had been put on concrete. Other treatments tested were ineffective in preventing the almost immediate breakdown of malathion on concrete surfaces. This is a serious problem in warehouses and milk processing plants.

(MQ 1-4)

Dermestid beetle larvae were exposed for 4 or 6 hours continuously, or for 2 hours at 24-hour intervals for a total exposure of 4 or 6 hours. This was to determine the effect on mortality of intermittent versus continuous exposure to malathion residues of 100 mg. per sq. ft. The average mortality was higher for the larvae exposed continuously.

(MQ 1-4)

The techniques and equipment for conducting laboratory mite fumigation tests were modified, improved, and evaluated. Unfortunately there are no established, proven procedures to follow in this work. The new method uses 12-liter boiling flasks for test chambers and magnetic stirrers to equalize the distribution of fumigant. A new mite handling technique uses a low temperature counting plate to eliminate the harmful effects of CO₂ as an anesthetizing agent.

(MQ 1-6)

A proportionate share of the research on insecticide evaluation at Savannah, Georgia, has been charged to the work on dairy products. Although many of the results are directly applicable, it is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore, the entire report is included in the cross-commodity report in Area 13.

3. Insecticide Residue Analysis. As with insecticide evaluation, the cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13.

4. Insect-Resistant Packaging. An additional packaging test has been completed in which different closures for multiwall paper bags containing nonfat dry milk were compared for their ability to prevent insects from invading the bags. Examinations were made after 1, 3, 6, and 12 months of storage during constant exposure to dermestid beetle infestation. An experimental hand-applied tape-over-stitching closure gave the best results. Stitching-over-tape and the normal sewn-open-mouth closures were less effective in the order named.

(MQ 1-13)

Additional cross-commodity packaging work conducted at Savannah, Georgia, is reported in Area 13.

Based on the results of several years of research on insect-resistant packaging, recommendations were made to CCC for improved closures on the packaging for nonfat dry milk. Specifications were worked up with the assistance of an industry association technical committee and have been adopted by the Department. Purchases are now being made under these specifications and it is anticipated the serious problems of insect infestation in storage encountered during the past several years will be considerably alleviated.

(MQ 1-13)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Moats, W. A. 1963. One-step chromatographic cleanup of chlorinated hydrocarbon pesticide residues in butterfat. II. Chromatography on Florisil. Journal Association Official Agricultural Chemists, 46: 172. (MQ 3-11)

Prevention of Insect Infestation

Hilsenhoff, William L., and Dicke, Robert J. May 1963. Effects of temperature and humidity on cheese mites--with review of literature. USDA Marketing Research Report No. 599, 46 pp. (MQ 1)

Marzke, F. O. 1963. Food preference studies with Trogoderma inclusum, a pest of the dry-milk industry. Journal of Economic Entomology, 56(1): 109. (MQ 1-4)

AREA 3

DECIDUOUS FRUIT AND TREE NUTS - MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Additional information is needed with respect to the accurate measurement of market quality and the effects that various handling practices and procedures have on the maintenance of quality. Objective measurements of quality would greatly assist in standardization and grading procedures and the development of instrumentation for this purpose greatly increases the chance for ultimate automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Consistently safe and effective transportation of the more perishable fruits can be accomplished only by continued research with transportation equipment and services as affecting ultimate quality of the product in the market. Dried fruits are subject to insect infestation from the time they are being dried in the field until they reach the final consumer. There is need for research to develop more effective measures to prevent this infestation all along the line, as raisins are drying in the field, during storage while they await processing, in the processing plant, and after they are packaged. Research is also needed to develop effective measures for protecting tree nuts against insect infestation during storage and after packaging.

USDA PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, food technologists and chemists. The research in horticulture includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include the laboratories at Beltsville, Maryland; field laboratories at Wenatchee, Washington; Fresno, California; and Raleigh, North Carolina; and market laboratories in Chicago, Illinois and New York City, and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Research on gamma irradiation of fruits and vegetables is underway at the Chicago and Fresno laboratories with some financial help from the Atomic Energy Commission. Cooperative

agreements and limited contributed funds were in effect with the California Strawberry Advisory Board and the California Tree Fruit Agreement. P.L. 480 supported research is underway in England on the effects of modified atmospheres on the physiological processes of apples; in Finland on fungicide residues on fruits as related to time and rate of spray application; and a project has just been initiated in Italy to study the principal rots of apples and pears.

Also there is a continuing long-term program at Fresno, California, which involves entomologists in applied research on the prevention of insect infestation, damage, and contamination of dried fruits and tree nuts in marketing channels. The research is conducted in cooperation with California State and County agencies and with several industry groups. Basic and developmental studies at Savannah, Georgia, involve entomologists and chemists whose research has cross-commodity application. The entire program is discussed in Area 13. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to dried fruits and tree nuts, only a proportional part of that effort has been allocated to Area 3.

Federal effort in this program totals 22.3 man-years divided as follows: objective measurement of quality 3.4; quality maintenance in handling and packaging 2.1; quality maintenance in storage 4.2; quality maintenance during transportation 1.2; postharvest physiology 1.8; postharvest disease control 4.2; prevention of insect infestation 4.3; and program leadership 1.1. Research under P.L. 480 includes a 4-year project in Finland on chemical residues for a total of \$56,637 equivalent; a 5-year project in England on the biological effects of modified atmospheres for apples at \$67,031 equivalent; and a new 3-year project just underway in Italy on apple and pear rots for \$18,357 equivalent.

Work terminated during the period included: packaging and cooling of blueberries (MQ 2-4); effect of varying temperature on quality of fruits (MQ 2-17); strawberry decay control (MQ 2-20); quality of dried fruits (MQ 2-9); quality changes in apples during marketing (MQ 2-38); storage of prepackaged apples (part of MQ 2-63); pectinase activity of juice extracted from decayed cherries for brining (MQ 2-16); and control of Drosophila flies in vineyards and fruit dumps (MQ 1-5).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern Apples. The Light Transmittance Difference Meter (L-TDM) was again used to determine maturity and quality of apples

in cooperation with the West Virginia Agricultural Experiment Station at Kearneysville.

Richared Delicious apples were harvested at intervals throughout the season. The high incidence of water core in the fruit reduced storage life and somewhat confounded the measurement of internal chlorophyll content, which was used as a measure of maturity and quality. Instrument readings, however, showed a gradual downward trend in chlorophyll content as the season progressed.

Titrateable acidity varied with no significant trend or relationship to the instrument reading. Starch content decreased rapidly at first as the fruit matured on the trees with gradual leveling off late in the season.

An automatic light transmittance fruit sorter (Fruit I. Q. Sorter) was received from the contractor. After some changes in optical design, preliminary tests were satisfactory.

Evaluations of the recently developed mechanical thumb were made during the season. Scale drawings of the device together with detailed specifications were prepared and submitted to interested manufacturers.

Exploratory tests were conducted using the L-TDM instrument in an attempt to detect internal browning in apples which develops in storage. Visibly sound McIntosh, Red Delicious and Stayman Winesap apples were sorted into 5 classes for chlorophyll content (measuring Δ .O.D. 695-740 mu) at harvest. After 6 months' storage at 30-31°F., the fruit was remeasured, with L-TDM, using wavelengths specific for internal breakdown, Δ .O.D. 720-820 mu. Objectionable internal browning from any cause was detected with 48-57% accuracy while severe internal browning was detected with 60-94% accuracy. (MQ 3-28)

2. Western Apples. Studies at the Wenatchee, Washington laboratory showed that apples of different sizes have different values on the Difference Meter scale for the same degree of water core. Consequently, the effect of size would have to be taken into consideration in the commercial separation of water-cored fruit by light transmittance determinations.

Dry weight of the apple tissue was not necessarily an indication of the amount of water core.

Water core intensity was followed through storage at temperatures of 31°F., 44°F. and 65° F. and relative humidities of 65 and 85 percent. Water core disappeared faster with increase in storage temperature. However, a shorter storage life and reduction in quality of the fruit accompanied the higher storage temperature.

Temperatures for the forty days following the 1962 apple bloom were considerably cooler than normal. Although a longer period from bloom to optimum maturity might be expected under these conditions, observations made on Starking Delicious picked at various periods from bloom indicated no great difference from previous years. When the fruit was examined in May (after 8 months' storage), that harvested at 140 to 150 days from full bloom had the best quality as judged by a panel of tasters. The density of the fruit increased and the chlorophyll content decreased with advanced harvest maturity. Apples with Difference Meter readings of 80 averaged 0.852 specific gravity, whereas those with D.M. readings of 30 averaged 0.895. (MQ 3-28)

3. Red Tart Cherries. Studies were conducted in Pennsylvania with a Light Transmittance Difference Meter (L-TDM) as a means of detecting scald. W.O.D. 730-800 mu was found specific for this disorder.

Evaluation of scald damage with the L-TDM and by visual external and internal ratings of cherries indicated that mechanical harvesting plus water tank hauling can result in cherries either comparable to or somewhat inferior to those handpicked and transported in field boxes or in water tank. The type of mechanical harvester and the care with which it is used appear to be the major factors determining incidence of scald damage and internal breakdown.

Samples of red tart cherries which graded 90-97 usable were found to be variable for anthocyanin pigment development ranging from 48-81 on the L-TDM. Such fruit was graded C and Sub-standard (primarily because of scald) when frozen. When heat processed in cans some cherries from the same lot graded A, but the major portion graded C and Sub-standard (primarily due to scald damage). A wider range of color for frozen than for canned product appeared acceptable for grade A, as long as uniformity was maintained in individual containers. Extremely dark cherries may be downgraded for color in the canned product according to the grade. (MQ 3-27)

B. Quality maintenance in handling and packaging

1. Eastern Apples. A study was made at Beltsville of ethylene accumulation within various sealed liners of apples. Ethylene was present within the different types of liners at concentrations of 500 to over 3500 ppm at the end of the storage period.

A rapid technique for positive identification of different kinds of films was developed using light at frequencies between 1.8 and 12.5 microns. Some chemical changes in liner compositions may occur during storage.

Liner permeability studies at 32° F. indicate that temperature relations probably depend on the activation temperatures of the plastics, and may be exponential, but these thermodynamic confirmations continue to be difficult. Equipment for a rapid method of gas transmission measurement at cold temperatures has been made and is being tested.

Pads and small bags containing 1 pound of fresh hydrated lime for absorbing CO₂ were packed within sealed polyethylene-lined corrugated boxes of Delicious, Golden Delicious, Rome, and Jonathan apples. Other boxes were packed without lime to determine the accumulation of CO₂ with and without lime in the liners in 32° F. storage. Previous tests had shown that a 1-lb. bag of lime was sufficient to keep CO₂ at 1% or below in a bushel of apples during 5-6 months' storage at 32°. Kraft paper pads (12x20 inches) containing lime, placed beneath the fruit, were as effective as kraft bags of lime for absorbing CO₂. The CO₂ averaged 6.1% within the liners without lime and 0.4% with the lime bags or pads. Small polyethylene bags containing 1 lb. of lime and perforated with 5 pinholes maintained an intermediate CO₂ level, averaging 4.1%. Delicious apples were 1 to 2 pounds firmer after storage when CO₂ was kept below 1% than when CO₂ was allowed to accumulate. Rome apples had less internal browning and soggy breakdown when CO₂ was held below 1% in film-lined boxes.

Ten tests conducted on 5 varieties of apples with 50 grams of activated carbon paper and brominated carbon paper packed within corrugated boxes of apples showed no benefits to keeping quality. Four of the tests were with polyethylene-lined boxes, 6 were without film liners.

One apple packer in West Virginia lost some Golden Delicious apples stored in folded-top polyethylene liners within corrugated cartons. This occurred after only 6-8 weeks in storage. Investigation by Beltsville and V.P.I. horticulturists disclosed that CO₂ had accumulated to 6-10% in many boxes, which is higher than ordinarily expected. Oxygen was at a low level of 1-2% in some boxes. Boxes with high CO₂ of 8-10% and O₂ below 3% were most severely injured; usually 50% or more of the fruit in such boxes had severe internal injury. The suffocation injury appeared much like soggy breakdown and the fruit was off flavored. Damaged fruit was much more prevalent in the larger sizes than in smaller sizes. Some fruit was injured even when CO₂ measured only 4-6% in December, but probably CO₂ was higher soon after harvest. At least four recommended procedures were followed by the grower: (1) the fruit was of good maturity for storage, (2) it was precooled before packing in film, (3) it was stored at 31°-32° F., and (4) the liners were 1.5-mil polyethylene. Two factors responsible for the suffocation injury are believed to be unusually high fruit respiration and too tight

a pack. The polyethylene was essentially sealed when an inverted molded-pulp tray was placed on top of the overlapped-film closure before lidding the boxes. The use of perforated liners, or liners which can not be heavily overlapped will be recommended in the future to avoid this injury. Use of hydrated lime inserts probably would have prevented the injury.

Jonathan and Delicious apples from 3 orchards were stored at 32° and 40° F.; half packaged in 4-lb. perforated polyethylene bags with 12 bags per shipping carton; and half, loose in field boxes. Fruit was examined monthly for 5 months. Rate of softening and amount of decay during storage were not appreciably different for apples in consumer bags or loose in boxes. Apples in film bags lost about half as much weight as fruit in boxes. Shriveling, a problem with some lots of Jonathans, was also reduced by storage in film bags.

The storage response of both varieties varied markedly between the 3 orchards, thus any general recommendation is limited. Film-bagged fruit stored for more than 2 months at 32° developed some scald, internal breakdown, and other defects that would necessitate repacking of some bags prior to sale. Use of the scald inhibitor, ethoxyquin, caused a slight browning of polyethylene bags when they were exposed to light for 2 or more days. This work on storage of prepackaged apples is completed. (MQ 2-63)

2. Western Apples. Consumer bags of nine different polyethylene formulations were tested at Wenatchee to determine their propensity for fogging or clouding when used for Delicious and Winesap apples.

The fruit was packed in the bags on December 26, 1962 and, after packing, the bags were placed in apple boxes and put into storage at 31° F. Two months later, on February 27, half of the bags of each lot were removed from cold storage and placed at 70° for observation for fogging. No fogging was visible when the packages were removed from 31°. After approximately a month, marked differences were apparent in the films. Fogging was more severe with Winesaps than with Delicious, but the tendency for the various bags to fog or resist fogging was the same for both varieties.

The bags classed as slightly fogged were not considered objectionable. All the bags had some spots that appeared to be from contact with the apples, but the spots were not typical fogging.

The remaining bags of fruit were removed from 31° storage on June 27, 1963 and examined after the condensation moisture had disappeared. Four of the bag films were clear while the remainder were cloudy or tacky. (MQ 2-63)

3. Peaches. In shipping tests from Georgia and South Carolina to northern markets, less bruising of peaches occurred in 38-pound Du-all crates (a combination wirebound and moistureproof corrugated container) than in the conventional tub baskets. An average of 5.7% of the peaches shipped in Du-alls were bruised in transit as compared to 10.2% of those shipped in baskets.

Bruising was also compared in Du-alls and non-moistureproof, corrugated cartons. Peaches shipped in the cartons were hydrocooled in field boxes prior to packing, while peaches in Du-alls were hydrocooled in the shipping container after packing. Bruising was about the same in both types of containers. Both containers held up well during transit.

In a comparison of bruising in conventional tub baskets and flat-top or (Pallet-Pak) baskets, 9.5% of the peaches in conventional baskets were bruised on arrival in the market and 8.9% in Pallet Paks. The percentage of peaches with cuts was greater in the Pallet-Pak than in the conventional basket. (MQ 2-33)

4. Blueberries. Results with fruit obtained from plants grown in in the greenhouse with 5 levels of N, P, K, Ca and Mg confirmed the previous season's results that nitrogen nutrition affected acidity, soluble solids, size, rate of ripening and keeping quality. These factors were associated with fruit: leaf ratios which indicate that high ratios (i.e. 7 to 8 fruit per leaf) decreased berry size, soluble solids, slowed ripening and increased acidity.

In 8 tests, in North Carolina, half cooling times were reduced from about 90 minutes to 30 minutes by modification of the master shipping container and the use of less expensive slotted pulp cups instead of the standard veneer till. Faster precooling aids in drying and maintaining quality of fruit harvested wet. Commercial harvesting is now delayed when the berries are wet. (MQ 2-4)

5. Pears. Preliminary studies on waxing Anjou pears in a commercial operation at Cashmere, Washington indicate that the process may have some beneficial effects in extending the storage life of the fruit. Waxing caused retention of the green color in some fruits during ripening. Carbon dioxide in the internal atmosphere of the pears was three times as high at removal from cold storage as in the unwaxed pears. After 10 additional days at 70° F. internal CO₂ was almost twice as high as that in the untreated fruit. Further work is needed to establish safe and effective wax compositions and practical application methods. (Exploratory Research)

C. Quality maintenance in storage

1. Eastern Apples. Sixteen lots of Red Delicious apples were stored at 32° F. for 6 months under different atmosphere of CO₂ and O₂ at Beltsville to observe the response of the fruit to different atmospheres and to record any injuries that developed.

Apples stored in atmospheres of 1 to 3% O₂ and zero CO₂ were practically free from physiological disorders following storage. At zero O₂ and zero CO₂ (100% N₂) a brown mottled injury similar to soft scald occurred on the skin of 80% of the fruit. Internally, 70% of the fruit from this atmosphere developed browning in the core area. With additions of CO₂ of 5, 10, or 15% in combination with zero O₂, these same types of injuries occurred. Externally, they were obscured and confounded by the appearance of a severe brown spotting indistinguishable from severe storage scald. Internally, only 19 to 41% of the fruit developed the core browning type of injury. All fruit of the zero O₂ treatments developed a slightly fermented flavor.

With O₂ at 1%, no off-flavors developed and the external soft-scald type of injury as well as core browning were negligible. With increasing amounts of O₂ in the absence of CO₂ mild scald-like symptoms developed externally and flesh breakdown, similar to soggy breakdown developed internally. When CO₂ was increased, along with higher oxygen, the severity of both the scald symptoms and breakdown increased markedly. (MQ 2-63)

2. Western Apples. Commercial "Tectrol" storage in which the desired atmosphere was maintained by a continuous flow of air, adjusted to the desired levels of oxygen and carbon dioxide before it was introduced into the storage room and conventional C.A. storage with 2 to 3 percent oxygen and 1 percent or less carbon dioxide, obtained by respiratory activity were compared with regular air storage for Delicious apples at Wenatchee, Washington.

The first fruit was removed after about 90 days' storage. This represented the minimum period required by Washington State law for C.A. fruit. Storage was terminated May 1, after a total of about 7 months. After both the short and long storage period firmness, soluble solids, and taste-panel rating were similar in the three lots of fruit. There appears to be little advantage of controlled atmosphere storage for Delicious apples in the Northwest. The principal difference observed was in the higher acid content of the C.A. fruit. More total scald and substantially more severe scald developed in the apples stored in the Tectrol room than in the fruit from the other storages. Work on C.A. storage of Northwestern Delicious is completed.

Relative humidity was studied as a factor related to the development of mealy breakdown of California-grown yellow Newtown apples after storage in controlled atmospheres. Apples examined immediately after storage (8 months at 42° F.) showed no breakdown, but after 10 days at room temperature, mealy breakdown developed in 23 percent of the fruit stored in an atmosphere of 3 percent CO₂ and 3 percent O₂ (3/3) at 100 percent RH, in 28 percent of that in a 6/3 atmosphere at 100 percent RH, and in only 4 percent of that held in a 6/3 atmosphere at 70 percent RH. Although lowering the relative humidity reduced mealy breakdown, the fruit held at the lower RH lost about 3.5 times as much weight as that held at the higher RH.

Fruit held at 100 percent RH in the 6/3 atmosphere was firmer and slightly greener than that held in the 3/3 atmosphere. Fruit held in the 6/3 atmosphere at 70 percent RH was similar in color and firmness to that held in the same atmosphere at 100 percent RH. (MQ 2-57)

3. Plums. California-grown Nubiana and Santa Rosa plums were sorted at harvest into groups differing in specific gravity and soluble solids by flotation in a graded series of sodium chloride solutions ranging from 4 to 10 percent NaCl. Specific gravities ranged from 1.03 to 1.07. Plums with high specific gravity and soluble solids had the best flavor and quality after ripening.

Nubiana plums stored in sealed, polyethylene box liners (1.5 mil) at 32° F., developed modified atmospheres of 7 percent CO₂ and 12 percent O₂, which reduced the rate of ripening in storage and during subsequent holding at 70° F. After 10 weeks' storage, plums held under modified atmosphere were not of high quality, but were much better in all respects than plums held in a normal atmosphere. The plums stored in modified atmosphere were harder, had lighter flesh color, had one-half as much decay, and had much better flavor than plums in normal atmosphere. (MQ 2-12)

D. Quality maintenance during transportation

1. Pears. Transit temperatures of early-season California Bartlett pears were correlated with time required to ripen the fruit after arrival at markets in New York City and Chicago. Early fruit, shipped to Chicago, required excessive ripening periods, even when a minimum amount of refrigeration was used in transit.

Single bunker cars, which use ice as a refrigerant and have thermostatically controlled fans, provided more nearly uniform load temperatures than standard ice cars. These cars were equipped with a ceiling duct to provide better air distribution in the car. Proper spacing of containers in the load was necessary to prevent cold air from bypassing the load and prematurely shutting off the thermostat. (MQ 2-84)

2. Strawberries. A series of experiments at Fresno, California simulating transit conditions for strawberries indicated that a mixture of 1-1-1 trichloroethane and dichloromethane sold commercially as Safe Delivery Vapor (SDV) was ineffective in controlling either Botrytis or Rhizopus rot of strawberries when used alone or in combination with carbon dioxide. This confirms the results of two shipping tests made with commercial loads during 1962.

Laboratory tests simulating the recommended carbon dioxide (dry ice) treatment during transit showed marked reduction in decay, compared to untreated controls. These experiments also demonstrated the danger of too high concentrations of carbon dioxide; concentrations above 50 percent for more than a few hours produced off-flavors. Good decay control was observed at about 30 percent CO₂, the maximum level likely to occur in rail car loads of strawberries treated with dry ice. (MQ 2-83)

3. Grapes. Thompson Seedless grapes packed in 28-pound TKV lugs were hydrocooled for 10 minutes and fumigated with 1.0 or 0.5 percent SO₂. The half-cooling time varied from 1 to 2 minutes. After 2 months' storage, weight loss from hydrocooled grapes averaged 0.5 pounds while that from comparable air-cooled fruit was about 1.8 pounds. The stems and berries were fresher in the hydrocooled fruit but 16 percent of the berries were split, compared to only 1.0 percent in the air-cooled fruit. Decay was similar in hydrocooled and air-cooled fruit.

Ribier grapes that were hydrocooled and stored 5½ months lost less weight and were slightly crisper and fresher looking than air-cooled fruit. However, wet berries were found in the center of some clusters in the hydrocooled fruit; wetness was more prevalent in fruit fumigated with 1.0 percent than with 0.5 percent SO₂. Decay was similar in the two lots of fruit.

Emperor grapes that were hydrocooled and stored at 32° F. for 40 days had greener and fresher stems and firmer and crisper berries than comparable fruit cooled initially in air. The color of hydrocooled fruit was brighter due to removal of dust from the berries. After 4 months' storage, the hydrocooled fruit was still in better condition than air-cooled fruit. Decay, mostly Alternaria, was not significantly different in hydrocooled or air-cooled fruit. (MQ 2-49)

4. Peaches. Observations were made on test shipments of South Carolina-grown Dixie Red and Coronet peaches to London and in one containerized military shipment of Coronet peaches to Germany. Transit temperatures ranged from 38° to 45° F., rather than the recommended 32° F. The Dixie Reds showed ripening of the flesh

one-fourth to one-half inch under the skin during transit. During the 4-day 60° to 65° ripening period at destination about 30 percent of the Dixie Reds developed brown rot. The fruit was mealy and lacking in flavor. The Coronets arrived with excellent appearance; showing little or no decay or bruising. During the 4-day 60° to 65° holding period, less than 1 percent decay developed.

Little difference in mechanical damage was noted between peaches in the 22-pound wooden containers and those in the fiberboard packages. However, considerable pilferage (average of 5 percent) occurred in the cartons. Fruit in bushel baskets showed three times as much mechanical damage as that in the 4/5-bushel wirebound crates. (Exploratory Research)

5. Simulated Transit in Nitrogen Atmosphere. Continued tests at Beltsville indicate that strawberries developed less decay at 33° F. in 100% nitrogen than in 99% nitrogen or in air. After treatment for 10 days, approximately 85% of the berries remained sound in the 100%-nitrogen atmosphere, as compared to about 48% sound in 99%-nitrogen and in air. Flavor of strawberries was not affected by holding in 99 or 100% nitrogen at 33° for periods up to 10 days. (MQ 2-71)

At Fresno, California oxygen concentrations of 1 percent or above had very little effect on rate of ripening, respiratory activity, flavor, or decay of strawberries. An oxygen concentration of 0.5% inhibited the rate of respiration and ripening but had little effect on flavor. The effect on decay was not determined. Zero oxygen inhibited ripening and the development of decay, but produced off-flavors with prolonged holding. (MQ 2-83)

E. Postharvest physiology

1. Apple Scald. At Beltsville, Red Delicious and Red Rome apples were separated into high, medium, and low internal chlorophyll content categories by light-transmittance techniques before storage. This was done for two pickings 10 days apart. Scald determinations made after 6 months at 32° F. plus 6 days at 70° showed that initial chlorophyll content was not a reliable indicator of scald susceptibility. Even low-chlorophyll apples from the first picking developed much scald. At the second (commercial picking) date, both high and medium chlorophyll content apples developed similar amounts of scald. Diphenylamine, used as a dip at 2000 ppm, was an effective scald inhibitor for high, medium, or low chlorophyll content apples, particularly when fruit was picked at a commercially acceptable date.

The two approved chemical scald inhibitors, ethoxyquin (Stop-Scald) and 83% wettable powder diphenylamine (DPA) were tested on Red Delicious, Stayman and Rome apples from commercial orchards. DPA

formulations from two sources were compared. Total scald in 8 tests after 5-7 months' storage at 32° F. averaged as follows: untreated, 56%; 2700 ppm Stop-Scald, 6%; 2000 ppm DPA 10% from one source and 14% from the other. Chemical injury from the scald inhibitors was negligible and keeping quality of fruit treated with the different inhibitors was otherwise similar. In a controlled-atmosphere storage in Pennsylvania, both Stop-Scald and DPA completely controlled scald on Stayman apples, while 64% of the untreated fruit was scalded after 7 months at 32° plus 7 days at 70°. The CA Staymans were 2 pounds firmer than similar apples in air storage on removal and 1 pound firmer after 7 days at 70°.

Dipping apples in 120°-130° F. water for 1-2 minutes before storage reduced subsequent scald development on Delicious, Stayman, Rome, and York varieties. The best control of scald with hot water was obtained on Stayman apples. Time-temperature tolerance of hot-water treatments for controlling scald was critical for apples and varied with varieties. They may vary too much for commercial application. Hot water dips of 20-30 seconds at 140° or 5 seconds at 150° usually injured the skin. (MQ 2-91)

An attempt was made to learn more about the mechanism involved in the control of apple scald with DPA by studying the inhibitory effects of DPA on the cytochrome electron chain. Earlier work indicated that DPA inhibited respiration insensitive to antimycin A and cyanide. Aged washed potato disks develop a type of respiration highly resistant to cyanide but sensitive to DPA. The antioxidants, butylated hydroxyanisole and butylated hydroxytoluene affected respiration very similarly to DPA. These findings indicate that the activity of DPA may be due to the formation of a reactive radical plus a hydrogen atom. This work has special significance in the study of cyanide-resistant respiration as well as the coupled phosphorylated pathway. (MQ P-1)

2. Apple Respiration in Modified Atmospheres. Additional information developed at the Ditton Laboratory in England under P. L. 480 shows that reducing oxygen to only 10 percent causes a definite reduction in respiratory activity of Cox's Orange Pippin apples in CO₂ free atmospheres. The data also indicate that CO₂ evolution is reduced more in atmospheres containing above normal amounts of CO₂ than in those free of added CO₂. Significant data have been obtained on aldehyde and alcohol accumulation in apple tissues as related to storage atmosphere. Rather surprisingly both aldehyde and alcohol content after storage at 32° F. were lower in 2% O₂ than in higher controlled O₂ or in air. This indicates that O₂ must be very low before anaerobic respiration occurs at 32°. (E29-AMS-1)

3. Anjou Pear Scald. The first season's results on this contract research at Oregon State University include useful information on relation of field temperatures during maturation and harvest maturity to scald susceptibility. Induced temperature increases to maturing fruits increased susceptibility to scald. Three pickings at weekly intervals indicated no consistent relationship between harvest maturity and scald development in storage.

Oiled wraps were compared with dips of Diphenylamine and Santoquin and also with wraps containing these compounds. Scald was severe on all untreated fruit. Santoquin applied as a dip or in wraps gave near perfect control. Diphenylamine as a dip or in wraps gave variable results from excellent to poor. Pears wrapped in oiled wraps were about 75% scald free after storage. (MQ 2-66)

4. Lenticel Spotting of Golden Delicious Apples. Golden Delicious apples of 3 color classes, yellow, white and green, were stored at 31° and 35° F. at Wenatchee with and without polyethylene liners for approximately 1 month before they were packed. The fruit was then packed without wraps, in molded pulp trays and perforated polyethylene liners in telescope fiberboard cartons. Only a small percentage of the fruit developed the disorder in one make of tray, while a relatively large percentage developed the disorder in the other make. Somewhat more injury developed at 35° than at 31°. It was most severe on yellow fruit, intermediate on white, and least on green. Although a third make of trays were not included in the laboratory experiments, observations on fruit packed commercially in these trays revealed a considerable amount of lenticel injury. A melamine-formaldehyde wet-strength resin was used in the manufacture of 2 makes of trays. Reports of work done on this problem in South Africa indicate that decomposition products of this resin are responsible for this disorder. The manufacturers of the trays have been informed of these data and have changed the resin used in trays manufactured for the 1963 crop of fruit. (MQ 2-72)

F. Postharvest disease control

1. Apples. Ten grower lots each of Delicious and Winesap apples were selected at random from the lots being assayed in the central culture room of a cold storage warehouse. The fruit was examined after 21, 28, and 35 days at 70° F. The amount of decay in these lots ranged from 2 to 5 percent, mostly blue mold rot in the first two examinations. After 35 days the decay picture was obscured by the development of pink mold rot, (*Cephalothecium roseum*) a high temperature organism which does not develop at cold storage temperatures. Samples of the same fruit held in cold storage were examined at 120, 150, 180, and 210 days. The amounts of decay in these lots of fruit ranged from 1 to 3 percent blue mold. In the lots containing water core the amount of breakdown that developed after 210

days in cold storage was only slightly less than that which developed after 28 days at 70°. (MQ 2-67)

2. Peaches. Twenty-three tests with hot-water-treated peaches included in commercial shipments from Georgia and South Carolina to northern markets were made during the summer of 1963. On arrival the peaches were held at 70° F. until they were eating ripe. In nine tests from Georgia non-heated, hydrocooled peaches developed an average of 24 percent brown rot, whereas an average of only 7 percent brown rot developed on peaches heated in 130° water before hydrocooling. The non-heated, non-hydrocooled peaches in these tests averaged 46 percent brown rot, while the heated, non-hydrocooled ones averaged 12 percent. In eight of the tests from South Carolina the non-heated peaches averaged about 5 percent brown rot and the hot-water-treated ones about 2 percent. Rhizopus rot in both Georgia and South Carolina test peaches was reduced by about one-third by the hot water treatments.

In 6 of the 23 tests, either brown rot or Rhizopus rot or both were greater in the hot-water-treated and hydrocooled peaches than in comparable non-heated peaches. Recontamination of the fruit during hydrocooling was suspected, since the hydrocooling water at the sheds in which the 6 tests originated was extremely dirty. This indicated that hot-water-treated peaches were more susceptible to infection in contaminated water than non-heated ones.

In supplemental tests at Beltsville peaches treated with hot water and hydrocooled in water containing brown rot or Rhizopus spores developed far more decay during holding at 50° and 70° F. than non-heated fruit. When 100 ppm chlorine was added to the hydrocooling water containing the spores, the heated peaches no longer developed increased decay. None of the spores from samples of the chlorinated water germinated when plated on agar and incubated in dishes at 70°. This demonstrates the need for careful sanitation in peach packing sheds if hot water treatments are to be effective.

In many of the test shipments a mottling type of injury appeared on some of the heat treated fruit. In most instances it was not severe enough to affect the acceptance of the fruit.

About 40 truckloads of peaches were treated in a hot water tank installed in a commercial packing house in Georgia. All treated loads were commercially acceptable, whereas other shipments during the same period often developed considerable decay. (MQ 2-22)

The effect of relative humidity on the survival of Monilinia or Rhizopus spores exposed to 120°, 130°, or 140° F. air was studied under laboratory conditions. When the relative humidity was 50 percent spores of either organism exposed 4 hours at any of the

three temperatures germinated almost as well as 70° at non-heated spores. However, when the relative humidity was raised to 80 percent, spores exposed for 2 hours had much lower viability than non-heated spores. Spores exposed to 90 percent relative humidity for 1 hour at any of the three exposure temperatures had less than 5 percent germination at 70°. (MQ 2-22)

Studies were continued at Chicago on an organism belonging to the genus *Phytophthora* which was isolated from Indiana peaches in 1962. The organism infects peaches through wounds or by contact. Mature sporangia placed in water at 40° F. readily form and release zoospores which retain motility for 5-10 minutes after release from sporangia. Germination of zoospores at 70-80° F. occurs 3/4-1 hour after escape from sporangia. (MQ 2-64)

3. Grapes. The distribution of SO₂ in conventional ice bunker refrigerator cars was determined when the car fans were operating. Distribution was poor when air was allowed to move freely through the floor racks at the brace, but a reasonably uniform concentration of SO₂ was obtained throughout the load when the floor rack was covered with paper to prevent by-passing of the SO₂ and air. Use of 2 percent salt to increase ice meltage increased SO₂ absorption by the melting ice to 20% more than ice without salt. Additional amounts of SO₂ were required to compensate for that removed by the ice water.

Respiration rates were compared for Emperor grapes fumigated at weekly intervals for 3 months with 0.1, 0.25, 0.5, or 1.0 percent SO₂. The respiration rate decreased progressively with increasing concentrations of SO₂. When berries from each treatment were immersed in water, the conductivity of the water increased with increased concentration of gas and also increased with the number of fumigations. This may be an indication of the degree of injury induced by SO₂.

After 6 weeks' storage, the capstems of Emperor grape berries, that were not fumigated with SO₂, were all infected with *Alternaria*. Only 6.4 percent of those fumigated with SO₂ were infected. When the brush was severed from the capstem, 74 percent of the brushes from the non-fumigated berries were infected and only 1.6 percent of the fumigated ones. No difference in *Alternaria* infection was found in grapes fumigated with 0.1, 0.25, 0.5, or 1.0 percent SO₂.

Berries inoculated with *Botrytis* were incubated for 18 hours at 50° F. and then dipped for 1 or 2 minutes in water containing 7.5, 6.0, 4.6, 2.8, or 0 percent dissolved SO₂. After 5 days at 50° F., berries dipped in water with no SO₂ were all decayed, but those dipped in any of the SO₂ solutions were free of decay. However,

all concentrations of SO₂, except the 2.8 percent, injured the fruit. Dipping the berries in a 2.0 percent sodium bisulfite solution also controlled decay, but left a residue on the skin. (MQ 2-49)

4. Blueberries. Berries from Maryland, New Jersey and North Carolina were dipped in hot water and in various fungicides before storage at Beltsville to evaluate effect on decay. Certain hot-water treatments were more effective than the fungicides in reducing decay, principally gray mold. Total decay after 4 days at 50° F. plus 7 days at 70° in six laboratory tests averaged 30% or more, when untreated, or dipped in 80° to 110° water, 1000 ppm Botran, or 0.5% sodium salt of dehydroacetic acid. When dipped 5 minutes in 120° water, 2 minutes at 125°, or 1 minute at 130°, decay ranged from 5 to 8%. A 30-second dip in 140° water severely damaged the appearance by removing the bloom. Slight heat injury occurred on fruit treated in 120 to 130° water in some tests. Fumigation with 0.25% SO₂ for 20 minutes reduced decay in some tests but injured the fruit.

Unsatisfactory results were obtained in 3 tests with hot-water treatments at commercial blueberry packing sheds in New Jersey. Spoilage, largely from *Rhizopus* rot, was more than doubled by the hot-water treatments. Apparently the berries were injured by the heat treatments and then were heavily contaminated with *Rhizopus*. Later tests showed that drying the berries after treating with hot water reduced decay appreciably. (MQ 2-45)

5. Cherries for Brining. The optimum pH of pectinase activities for the juice extracted from cherries rotted by *Cytospora leucostoma*, *Aspergillus niger* and *Penicillium expansum* were pH 3.0, 4.5, and 6.0, respectively. Tests for galacturonic acid were positive for all organisms. Incubation of enzymes in the presence of bisulfite brine reduced activity by 1.5, 2.2, and 8.9%, respectively for *Cytospora*, *Penicillium*, and *Aspergillus*. This work has been completed. (MQ 2-16)

6. Red Raspberries. Fumigation with 0.25% SO₂ gas for 20 minutes or a 30-second dip in 0.5% sodium salt of dehydroacetic acid substantially reduced decay. In ten tests at Beltsville salable berries after 4 days at 60° F. were as follows: Nontreated 42%; dipped in room temperature water 25%; dipped for 30 seconds in .5% sodium salt of dehydroacetic acid 78%; treated with .25% SO₂ gas for 20 minutes 63%. (MQ 2-45)

7. Cranberries. A series of hot water treatments were evaluated as a means of reducing spoilage of cranberries in storage. Cranberries immersed in 125°, 120°, 115° and 110° F. water for 2.5, 5, 10 and

20 minutes, respectively developed about one-half as much spoilage over a 6-month storage period at 38° plus 7 days at 70° than non-treated berries. Also, cranberries stored continuously at 70° after the hot water treatments developed significantly less spoilage after 6 weeks than non-treated berries. (MQ 2-45)

8. Strawberries. Market surveys have shown the presence of Phytophthora and Rhizoctonia spp. on California strawberries. These diseases have not been heretofore reported from California. (MQ 2-64)

9. Gamma Radiation Treatments. Through an arrangement between the U. S. Atomic Energy Commission and Atomic Energy of Canada, a mobile irradiator (cobalt source) was made available to the Fresno, California laboratory last June. During the summer and fall of 1963 this has been used to determine, on a pilot scale, the value of gamma irradiation for the control of spoilage in fruits and vegetables and for its effects on the ripening and quality of the products discussed below:

(a) Plums--Four plum varieties, Santa Rosa, Eldorado, Laroda, and Wickson, were irradiated with doses of 125 to 500 krad. Color development was inhibited in proportion to the dose in all varieties. The irradiated fruit softened more rapidly than the untreated and developed very little flavor as it ripened. When ripened immediately after irradiation, only the Wickson plum was obviously injured, but after 2 to 6 weeks' storage, none of the irradiated fruit ripened as well as the controls; plums treated at the higher doses were inedible.

(b) Strawberries--Two varieties of strawberries, Shasta and Z5A, from the Salinas-Watsonville area were irradiated with doses of 100 to 300 krad. Decay due to Botrytis, Rhizopus, and Phytophthora was sharply reduced by doses of 200 to 300 krad. The Z5A variety was injured slightly by 300 krad.

(c) Peaches--Cardinal, Red Globe, Suncrest, and Fay Elberta peaches were treated with doses of 45, 125, 200, and 300 krad of gamma irradiation. Response varied with varieties. Cardinal peaches were injured by even the lowest dose and Rhizopus rot increased as a result. Decay did not develop appreciably in any other variety. The effect of irradiation on softening was inconsistent; irradiated Cardinal and Red Globe fruits became softer than untreated fruit; irradiated Suncrest softened less, and there was little effect on Fay Elberta. Doses of 125 krad or higher increased the development of red color during storage. However, doses of 200 and 300 krad produced a distinct loss of flavor.

(d) Nectarines--Sun Grand nectarines were treated with doses of 45, 125, 200, and 300 krad. There was no apparent beneficial effect of irradiation. Firmness was not influenced. Increasing doses resulted in increasing redness of the fruits, but also in a progressive loss of flavor. No decay developed in either treated or untreated fruit.

(e) Pears--Bartlett pears irradiated at 100, 200, 300, and 400 krad were harder and retained more green color than untreated fruit after 6 days at 60° F. Among the irradiated lots, the fruit treated with the lowest dose was the hardest and the greenest. After an additional 4 days the fruit in the lot having the low dose had ripened more rapidly than the higher doses. (MQ 2-82)

10. Pesticide Residues. A P.L. 480 project underway in Finland has developed additional information on residues of captan, malathion, particularly as related to absorption and disappearance of these materials from plant tissues. Using labeled isotopes they have followed translocation of malathion by autoradiography.

Studies on CIPC and IPC analyses and residues were initiated during the past year. Accurate methods of analysis have been devised and residue studies are underway with plums, apples, and some vegetables. Tests to date indicate that residues of these two compounds are relatively stable in stored products. A new series of tests is underway to determine the effects of malathion, captan, CIPC and IPC on storage life and decay development in fruits. (E8-AMS-1)

G. Prevention of insect infestation

1. Insecticide Evaluation. A proportionate share of the program at Savannah, Georgia, has been charged to this area. Although much of the work is directly applicable, it is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13.

2. Insecticidal Control. A single early application of 2-percent endrin dust on grape vines at the rate of 50 pounds per acre at the time the first vinegar fly infestation appeared failed to give any control, based on the amount of clean grapes harvested. Two treatments of 4-percent naled dust at 50 pounds per acre, applied 1 week apart and starting 2 weeks after the first infestation appeared, held the increase of infested grape clusters to 7 percent. There was a 16-percent increase of infested clusters in untreated grapes. A combination of the early endrin treatment and 2 subsequent naled treatments permitted an increase of only 3 percent of infested clusters. An alysis of data obtained the last two years shows that

timing of insecticidal dust applications and the degree of infestation at the time of the first treatment are more important factors for successful control than are the kind of insecticide or application rate, when the insecticides are dibrom, dimethoate, endrin, malathion, or naled, and the application rates are 35 or 50 pounds per acre. The dust treatments not only reduced vinegar fly infestations but indirectly reduced the spread of bunch rot, which is the most serious disease of ripening grapes in California. This in turn increased the yield of harvestable grapes. (MQ 1-5)

DDVP has given promising results in some preliminary tests against vinegar flies in wineries. Static cylinders releasing a steady known amount of DDVP vapor gave consistent kills of the flies but the cylinders were apparently not used in sufficient numbers to produce enough vapor for complete control. DDVP aerosol was applied in some large wine storage rooms. Fly trap counts indicated good control for 3 to 5 days after treatment. Air samples taken immediately after treatment and analyzed for DDVP showed a great variation in concentration in different parts of these large rooms. Studies will be continued to find ways to get higher concentrations or more uniform distribution of the DDVP vapor, thereby improving the fly control. (MQ 1-5)

Preliminary studies with malathion-treated raisin drying trays for the 1961 crop gave highly promising results and created great interest in the industry. An expanded study was conducted on the 1962 crop with trays containing 33, 150, and 300 mg. of malathion per square foot and untreated trays for controls. At the end of the drying period about 70 percent of the insects attracted by the drying grapes and found on untreated trays were alive. Nearly 100 percent of the insects found on treated trays were dead. At least 12 species of insects were found on the trays. In a supplemental test uninjured and field-run grapes were placed on malathion-treated trays to dry. At the end of the drying period over 80 times as many insects were found on the trays of field-run grapes as on the uninjured ones. (MQ 1-5)

Chemical analyses of malathion-treated raisin trays at the time they were put in use and at the end of the drying period showed a reduction in malathion deposit during that period to one-tenth to one-twentieth the original level. At the same time malathion was being deposited on or in the raisins. After drying, some raisins were placed in "biscuit rolls" and some in "cigarette rolls." Those in the former type contained 2 or 3 times more malathion when they were removed from the rolls. Additional tests will be conducted on the 1963 crop to find whether the same results are obtained. (MQ 1-5)

The test raisins were placed in typical farm storage upon removal from the field. Samples were taken at that time and after 3, 6, and 9 months of storage for chemical residue analyses. Samples were also processed at intervals to determine the amount of malathion removed during processing. Processed raisins containing 9.6 ppm of malathion were subjected to flavor and odor tests by an expert panel. No adverse flavor or odor attributable to malathion was detected by the panel. The chemical residue data and other pertinent information are to be considered by the Food and Drug Administration in connection with a petition for a malathion tolerance that would permit the commercial use of malathion-treated raisin drying trays. Such trays should not be used until or unless a tolerance is established. (MQ 1-5)

Observations were made on the status of insect infestation in the raisins during the 9 months of farm storage. At the end of that time the insect population seemed to be increasing in the raisins that had been dried on trays containing 33 mg. per sq. ft., but there were still only about one-fourth as many as in the raisins from untreated trays. Raisins from trays with 150 or 300 mg. of malathion per sq. ft. were almost completely free of any living insects after 9 months of storage. Laboratory bio-assay tests indicated that as little as 2 ppm of malathion on raisins will prevent the development of the Indian-meal moth and the saw-toothed grain beetle, two major pests of stored raisins. (MQ 1-5)

Fumigation studies relating to stored tree nuts were deferred during this reporting period to give emphasis to the raisin tray work. (MQ 1-10)

3. Insecticide Residue Analysis. The cross-commodity residue analysis work at Savannah, Georgia, is reported in Area 13. Some analyses were also conducted by industry cooperators.

4. Insect-Resistant Packaging. The cross-commodity packaging research at Savannah, Georgia, is reported in Area 13.

A cooperative study between the Fresno and Savannah stations was designed to determine the ability of insects to invade packages used by the date industry. The types of packaging evaluated were a plastic cup with a friction-lock lid, a plastic cup with polyethylene lid, and boat-pack containers with overwrap. The Fresno phase of the study has not been completed. Replicated groups of the filled containers were exposed for 6 months to heavy populations of stored-product insects at Savannah. A few of the boat-pack containers were invaded by insects, apparently through faulty end seals. The other containers remained insect free. (MQ 1-22)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality.

Olsen, K. L., Schomer, H. A., and Birth, G. S. 1962. Detection and Evaluation of Water Core in Apples by Light Transmittance. Wash. State Hort. Assoc. Proc., Vol. 58, pp. 195-197. (MQ 3-28)

Schomer, H. A., and Olsen, K. L. 1962. A Mechanical Thumb for Determining Firmness of Apples. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 61-66. (MQ 3-28)

Schomer, H. A., Olsen, K. L., and Yeatman, J. N. May 1963. A Mechanical Thumb for Measuring Firmness of Fruits. Marketing Bulletin No. 25. (MQ 3-28)

Quality Maintenance in Handling and Packaging.

Ballinger, W. E., Kushman, L. J., and Brooks, J. F. 1963. Influence of Crop Load and Nitrogen Applications Upon Yield and Fruit Qualities of Wolcott Blueberries. Proc. Amer. Soc. Hort. Sci., Vol. 82, pp. 264-276. (MQ 2-4)

Ceponis, M. J., and Kaufman, J. 1963. Some Effects of Packaging and Merchandising on the Quality of McIntosh Apples in New York City. Agricultural Marketing Service Report No. 494. (MQ 2-38)

Hardenburg, R. E. 1963. Controlling Carbon Dioxide Concentrations Within Sealed Polyethylene-Lined Boxes of Apples, Oranges and Lettuce with Hydrated Lime Inserts. Proc. Amer. Soc. Hort. Sci., Vol. 82, pp. 83-91. (MQ 2-63)

Hardenburg, R. E., and Anderson, R. E. 1963. A Comparison of Polyethylene Liners and Covers for Storage of Golden Delicious Apples. Proc. Amer. Soc. Hort. Sci., Vol. 82, pp. 77-82. (MQ 2-63)

Hruschka, H. W., and Kushman, L. J. 1963. Storage and Shelf Life of Packaged Blueberries. Marketing Research Report No. 612. (MQ 2-4)

Quality Maintenance During Transportation.

Harvey, J. M., Ceponis, M. J., Smith, M. A., and Harris, C. M. 1963. Ripening of Early-Season Bartlett Pears Shipped at Various Transit Temperatures--1962 Season. Agricultural Marketing Service Report 502, 12 pp. (MQ 2-84)

Kushman, L. J., and Ballinger, W. E. 1962. Forced-Air Cooling of Blueberries. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 281-287. (MQ 2-4)

Ryall, A. Lloyd. 1963. Effects of Modified Atmospheres from Liquefied Gases on Fresh Produce. Proc. 17th Nat'l Conf. Handling Perishable Agric. Commodities, pp. 21-24. (MQ 2-71)

Postharvest Physiology.

Lieberman, M., and Mapson, L. W. 1962. Inhibition of the Evolution of Ethylene and the Ripening of Fruit by Ethylene Oxide. Nature, Vol. 196, pp. 660-661. (MQ P-1)

Lieberman, M. 1961. Oxidative Activity of Cytoplasmic Particles from Rome Beauty Apple Fruit. Proc. IX Internat'l Botanical Cong. Sec. II, pp. 1168-1172. (MQ P-1)

Postharvest Disease Control.

Beraha, L. 1962. Influence of Gamma Radiation Dose Rate on Decay of Citrus, Pears and Peaches (Abst.). Phytopathology, Vol. 52, p. 3. (MQ 2-32)

Lewis, J. C., Pierson, C. F., and Powers, M. J. 1963. Fungi Associated with Softening of Bisulfite Brined Cherries. Applied Microbiology 11: 93-99. (MQ 2-16)

Smith, M. A. 1963. Apple Rot Caused by Pyrenochaeta mali n. sp. Phytopathology, Vol. 53, pp. 589-591. (MQ 2-64)

Smith, W. L., Jr. 1962. Chemical Treatments to Reduce Post-harvest Spoilage of Fruits and Vegetables. Botanical Review, July - Sept. 1962, pp. 411-445. (MQ 2)

Smith, W. L., Jr. 1963. Reduction of Postharvest Brown Rot and Rhizopus Decay of Peaches with Hot Water. Plant Disease Reporter 46(12): 861-865. (MQ 2-22)

Smith, W. L., Jr. 1963. Heat Treatments to Reduce Peach Decays. Talk presented at National Peach Council Convention, Atlanta, Ga., 1963, in Convention Presentations: 47-51; and for "Peach Times". (MQ 2-22)

Smith, W. L., Jr., and Bassett, R. D. 1963. Hydrothermal and Hydrothermal Inactivation of Monilinia fructicola and Rhizopus stolonifer Spores (Abst.). Phytopathology 53:747. (MQ 2-22)

Prevention of Insect Infestation.

Nelson, H. D., Spitler, G. H., and Yerington, A. P. 1963.

Protecting Raisins Against Insects During Drying and Storage with Malathion-Treated Trays. USDA Marketing Research Report No. 594, 18 pages. (MQ 1-5)

Yerington, Albert P. Control of Drosophila in Vineyards. Paper presented at Annual Research Conference of Dried Fruit Association of California, Monterrey, California, June 24, 1963, and published in proceedings. (MQ 1-5)

AREA 4

GRAIN - MARKET QUALITY

Problem.

Grain and cereal products are subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of micro-organisms, and by the attack of more than 50 species of stored-product insects. Safe storage of grain, flour, and cereal products for extended periods is a problem of immediate concern to military and civilian defense agencies. To maintain the quality of these products, more precise information is needed on the changes that occur in handling, storage, and transportation of these materials and of the products manufactured from them. To insure uniform and standardized products in the marketing channels and more equitable prices to all concerned, new and improved methods and techniques for measuring quality factors need to be developed for use in the inspection, grading, and standardization procedures. There is urgent need for more effective methods for preventing insect damage and contamination during storage, handling, processing, packaging, transportation, and retail distribution. The need is critical for effective pesticides and application methods that can be used in the marketing channels without leaving objectionable residues. Even more desirable is the development, wherever possible, of effective preventive and control measures utilizing biological, physical, mechanical or other nonchemical means that would reduce or completely eliminate the application of pesticidal chemicals

USDA PROGRAM

The Department has a continuing program involving chemists, engineers, and plant pathologists in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Maryland, and Watseka, Illinois, and also by research contract with Shuman Laboratories, Battle Ground, Indiana.

The program includes the following foreign projects under PL 480: A grant to the Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves PL 480 funds with a \$103,785 equivalent in Israeli pounds.

A grant to the Agricultural Higher School, Poznan, Poland, provides for a study of the effect of microflora of wheat flour on its stability, biochemical, and technological properties. Its duration is 4 years, 1961-1965, and involves \$13,091 equivalent in Polish zlotys.

Also, there is a continuing program involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels.

The work at Manhattan, Kansas, and Tifton, Georgia, is in cooperation with the respective State Agricultural Experiment Stations. The work at Tifton, Manhattan, Savannah, Georgia, and Watseka, Illinois, is in cooperation with the Agricultural Stabilization and Conservation Service, and one professional man-year of effort at Manhattan, Savannah, and Watseka is supported by Commodity Credit Corporation funds. The CCC also makes available various commodities and storage facilities for experimental use. There is cooperation with engineers of the Transportation and Facilities Research Division on matters relating to storage structures and aeration; and with the Field Crops and Animal Products Branch of this Division in studies relating to quality maintenance during storage, and on quality evaluation of grains and cereal products. There is cooperation with growers co-operatives at Manhattan and with various industry groups at all locations. There is also overall cooperation with the State Experiment Stations in Regional Project WM-16, "Maintaining Grain Marketability by Insect Control in Storage."

Much of the work at Savannah, Georgia, has cross-commodity application. Although the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to grain and cereal products, only a part of the manpower has been charged to this area. The entire program is discussed in Area 13.

Contract research included work with the University of Georgia, Athens, Georgia, and the Auburn University Agricultural Experiment Station, Auburn, Alabama.

A contract with the Hebrew University in Rehovot, Israel, provides for extensive studies on the effect of ethylene dibromide-fumigated feed on domestic farm animals. It became effective in 1961, continues to September 1964, and involves PL 480 funds with a \$98,197 equivalent in Israeli pounds.

Another contract with the Hebrew University at Jerusalem, Israel, is for a study of the influence of environmental conditions on the population dynamics of the khapra beetle. It became effective in 1961, continues to October 1964, and involves PL 480 funds with a \$44,296 equivalent in Israeli pounds.

A contract with the Administration of Agricultural Reserves and Surpluses, Montivideo, Uruguay, is for the study of underground storage of corn in airtight silos in relation to maintaining quality and preventing insect infestation during long-term storage. It became effective in 1962, continues to May 1967, and involves PL 480 funds with a \$59,906 equivalent in Uruguayan pesos.

A contract with the Instituto Superiore di Sanita in Rome, Italy, is to study the fate of insecticide residues on wheat during storage, milling, and baking or processing into wheat products. It became effective in 1963, continues to March 1967, and involves PL 480 funds with a \$98,319.16 equivalent in Italian liras.

A contract with the Direzione Generale dell' Alimentazione, Ministry of Agriculture and Forests, Rome, Italy, is for the study of insect infestation in macaroni, noodles, and spaghetti, and of ways to prevent this infestation. It became effective in 1962, continues to November 1965, and involves PL 480 funds with a \$42,621.90 equivalent in Italian liras.

The Federal scientific effort devoted to research in this area totals 24 professional man-years divided as follows: Quality maintenance and evaluation 6.0; basic biology and ecology 3.6, insecticide evaluation 1.8, and nonchemical control 0.6 at Manhattan, Kansas; insecticide evaluation 0.8, and nonchemical control 0.2 at Tifton, Georgia; insecticidal control 0.3 and nonchemical control 0.7 at Watseka, Illinois; insecticide evaluation 2.1, insecticide residue analysis 2.0, and insect-resistant packaging 2.5 at Savannah, Georgia; program leadership 2.4 at Hyattsville, Maryland; and contract research 1.0.

Line project MQ 1-8(C), a study of the effects of ethylene dibromide fumigant mixture on egg laying, was discontinued with the completion of the contract research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Quality Indicators for Stored Wheat. Samples of the hard red winter wheat varieties, Triumph, Bison, and Red Chief, and the hard red spring wheat varieties, Spinkcota, Selkirk, and Conley, of the 1962 crop were stored for 44 weeks at 75° F. Sedimentation values decreased during the storage period with the greatest decline exhibited by the two hard red spring varieties, Selkirk and Conley. The fat acidity values increased faster near the end of storage period than initially. The generally recognized poor quality wheat varieties, Red Chief, and Spinkcota, showed in general less changes in

quality due to storage than the strong, good quality wheats. Samples of the highest moisture level of 16 percent evidenced generally greatest decline in overall quality, with the 14 percent moisture samples less, and the 12 percent moisture samples the least. Grain stored at 86° F. declined more in chemical, baking, and other quality properties than wheat stored at 75° F. (MQ 3-3)

2. Effect of Excessive Heat on Corn Quality During Artificial Drying. (a) Reducing sugar content and diastatic activity. Among the chemical and physical properties of the corn grain examined as possible indices of damage by high temperatures during artificial drying, diastase activity was the property having the greatest differential between unheated samples and samples dried at 200° F. Diastase activity demonstrated an inverse linear correlation with increasing drying temperatures significant at the 1 percent level. Diastase activity was more sensitive to inactivation by heat than esterase activity or dehydrogenase activity as measured by tetrazolium salts, but it did not have sufficient accuracy or repeatability for predicting heat damage in corn. Diastase activity was not greatly affected by grain moisture in the range of 7 to 21 percent.

(b) Corn tenderness as an indication of damage by heat. Although this technique has been used successfully in assaying tenderness of various commodities, little or no correlation was found between corn tenderness and damage by heat.

(c) Viscosity measurements of mixtures of ground corn and dilute alkali solutions as an indication of damage by heat. Preliminary tests with this technique indicated that mixtures of ground heat-damaged corn and dilute alkali solutions gave higher viscosity readings than mixtures containing ground unheated corn and dilute alkali solutions.

(d) Moisture distribution in corn samples as an indication of damage by heat. This technique involves making a high frequency electrical capacitance measurement which is directly related to the total moisture content of the corn sample and subsequently making a direct current resistance measurement of the same sample. The resistance values are inversely related to the logarithm of the surface moisture of the corn sample. When the capacitance and resistance values for normal, undamaged corn are plotted on a semilog chart a straight-line curve is formed. The values for damaged corn, when plotted, are offset from this straight-line curve in an amount which appears to be related to the amount of damage to the corn. A significant correlation ($r=0.85$) was obtained between the magnitude of the offset in units of capacitance and the starch yield percent. The series of samples used were artificially dried by the Transportation and Facilities Research Division facility at Purdue University and the starch yield determinations were made by the Shuman Chemical Laboratories of Battle Ground, Indiana.

This offset value may also have some relationship to the viability of the corn but further investigative work is needed before any conclusion can be drawn.

(e) Glutamic acid decarboxylase activity as an indication of damage by heat in corn. This technique is being evaluated and improved. It appears to have some merit as a laboratory method and should serve as a check on other methods. (MQ 3-18)

3. Moisture Measurement and Equilibria in Grain. (a) Spectrophotometric measurement. A modified near-infrared spectrophotometric method of moisture determination of wheat has been developed. The methanol extraction of the earlier method is eliminated saving considerable time. It makes use of the fact that water absorbs light at 1.93 microns wavelength. The extent of the absorption depends upon the amount of water present in the sample of ground wheat through which the light passes. Results obtained for ground wheat show that sensitivity of 0.1 percent is readily obtained.

(b) Study of hysteresis. A new approach to the study of hysteresis effects in wheat has been undertaken. Kernels of wheat of known moisture content which have been colored with an organic dye are mixed thoroughly with other kernels which are not dyed and have a different known moisture content. The mixture is held in a sealed container at constant temperature until equilibrium conditions are attained. This requires approximately 40 days at 76° F. The hysteresis effect is determined by separating the dyed from the undyed kernels by hand and making a moisture determination on each. When the original difference in moisture content between the dyed and undyed kernels is approximately 5 percent the difference between them at equilibrium at 76° F. is 0.7 percent. This difference at equilibrium gradually decreases as the original difference in moisture content falls below 5 percent. Studies are also being made on the effect on this equilibrium of temperature, pressure, kernel size, relative weights of high and low moisture kernels and successive wettings and dryings. (MQ 3-23)

4. Sampling Research. Cooperative agreements were prepared and signed to cover research on the mechanical sampling of grain. Grain industry cooperators include Cargill, Inc., South Dakota Wheat Growers Association, R. F. Gunkelman & Sons, Farmers Union Grain Terminal Association, and F. H. Peavey and Company. Mechanical sampler manufacturers include the Dean Gamet Company, The Gustafson Manufacturing Company, The Erling K. Strand Company, Wilson Machinery Company, and Canadian Anglo Machinery and Equipment Company. Grain sampling research was conducted at Wolf Point, Montana; Aberdeen, South Dakota; Grandin, North Dakota; Minot, North Dakota; Crookston, Minnesota; and Minneapolis, Minnesota. Various lots of wheat and barley were carefully cleaned to our specification. Typical screenings were added to

these lots to provide grain with known FM and dockage content. The grain was sampled mechanically as it was loaded into boxcars. It was resampled by standard grain probes and by additional mechanical probes as it moved to destination and during unloading following a plan developed to yield maximum statistical data.

Research was directed toward designing and building a pneumatic sampler to meet the needs of the Watseka Bin Storage Project. Air-flow requirements were measured and an experimental double-wall sampling tube built. A second pneumatic sampler of improved design has been built and is ready for testing. (MQ 3-24)

5. Standardized Lighting Conditions for Grading Grain. The color background work mentioned in the 1962 report has been completed and preparation of a manuscript is in progress. After screening numerous materials and background colors, four selections were made for more concerted study with the Macbeth TC 440 examolite as a light source.

A total of 2,520 examinations were made. Analysis of the data by the "Duncan test" method, using the data of all nine men, failed to show significant differences between colors on some commodities. When data were stratified into two groups, based on experience of the nine men, and reanalyzed, 66.6 percent of the data showed a definite difference in results obtained on buff and blue X backgrounds. (MQ 3-30)

6. Test Weight-Flour Yield. The four general classes of wheat have been studied to find what physical and chemical characteristics are related to flour yield. So far, the following factors have been studied: Test weight per bushel, 1,000-kernel weight, density, average kernel volume, kernel size, pentosan content, pearling index, and bran content. Statistical analyses of the test results are not yet complete, but for the hard red winter wheats all these factors show significant correlations with flour yield. There are indications that all the classes do not exhibit the same milling behavior and therefore the correlations of these factors with flour yield cannot be expected to be the same for all classes. The results of these analyses will be used to develop better methods for predicting flour yield. (MQ 3-36)

B. Quality maintenance in storage

1. Oxidative Deterioration of Dried Corn. The results of these studies indicate that corn seed with a moisture content of 8 percent or less, can be stored at 68° F. and below at levels of oxygen ranging from 0 to 100 percent, without a severe reduction in germination or growth of seedlings. Methods of chemical analysis were adapted to study injuries on very dry corn in storage caused by oxygen.

In general, peroxide formation was not directly related to the storage life and vigor of the seed. Assays for carotenoids showed a decline of pigments during storage which apparently was correlated with the amount of oxygen in the storage atmosphere. This loss of pigment appeared to be one of oxidation and was not correlated with seed moisture. No significant variation was revealed between the total fat content of seeds of different moisture contents stored at different oxygen levels. Results of phosphorous analysis were disappointing due to lack of suitable methods for analyzing the small fractions involved. Studies of conductivity of seed leachates indicated that results of these tests might be more reliable in the general assessment of stored grain rather than as tests for germination.

Respiration studies of very dry corn revealed extremely low rates of carbon dioxide production. These results and other corroborative evidence could suggest that the carbon dioxide obtained was not the result of enzymatic respiration. (MQ 2-34)

2. Corn Storage Research. Studies of the effect of various chemicals as inhibitors of fungus development showed little promise and were discontinued. Sampling and pathology tests on corn stored at the CCC binsite have been continued and are revealing the organisms infecting the corn. Studies of the airborne fungi in the atmosphere of the binsite, both in the bin and surrounding atmosphere, have been initiated. In addition, the survey of the total fungus population of the stored corn is being continued. (MQ 0-0-2 (CCC))

3. Microflora of Wheat. In PL 480 research being conducted in Poland, seventy-eight samples of Polish wheat and eight samples of wheat imported from the United States and the Soviet Union were evaluated qualitatively and quantitatively with regard to their external and internal microflora. This microflora was found to consist of 62 species of bacteria and 58 species of fungi. These results are in line with those reported by numerous other investigators and did not reveal the presence of any previously unreported species. No significant differences in microflora were found among the 78 soft wheat samples of the 1961 crop from 17 areas of Poland. Ten samples of the 1962 crop from the Poznan region were found to be virtually free of internal fungi and bacteria. Eight hard wheat samples from the United States and the Soviet Union were found to be completely free of internal fungi and bacteria. No significant differences were found between the degree of external contamination of the imported wheat and that of the Polish wheat.

It was found that one species of an aerobic, spore-forming bacillus consisted of several biochemical strains and it is believed that this finding may be of "great practical significance, as far as the qualitative evaluation of flour is concerned." A number of fungi and spore-forming bacteria exhibited marked antagonism toward Bacterium herbicola.

If it can be assumed that B. herbicola is one of the dominant bacteria on healthy seeds, then its presence might serve as an indicator of the health condition of grain. (E21-AMS-7(k))

4. Underground Storage of Corn. This research project concerned with the underground storage of corn in airtight silos is being done in Uruguay under a PL 480 grant. After preliminary studies, experiments were started on the construction of underground silos. Two experimental silos have been constructed each to hold 550 tons. Both are now ready for corn and the actual research study is being initiated. (S9-AMS-6(a))

C. Prevention of insect infestation

1. Basic Biology and Ecology. In a study to find whether the air movement in mechanically aerated bins of grain has adverse effects on stored-grain insects, it was found that the interstitial air in all nonaerated bins contained a percentage of carbon dioxide considerably in excess of that in normal air or in aerated bins. This condition existed in wheat, corn, and grain sorghum in 3,250-bushel circular metal bins where observations were made over a period of 3 months. There was a pronounced reduction in carbon dioxide concentration of interstitial air in bins aerated with outside air after 2 weeks of fan operation at the normal airflow rate of 0.1 cubic foot per minute. No correlation was evident during the period of observation between changes in grain temperature or moisture within a bin and the composition of the interstitial air in the same bin. (MQ 1-18)

A series of laboratory tests was conducted to determine the effect on the development of rice weevils in aerated wheat by varying temperature, relative humidity, or rate of air movement, one factor at a time. Twenty 3-inch diameter downspout tubes filled with wheat were used in each test, and they were placed in a small insulated room where the temperature and relative humidity were maintained at a constant preselected level. At 80° F. and 60% relative humidity, conditions favorable to the insects, the nonaerated tubes produced fewer progeny than did the aerated tubes. The air circulation tended to increase the moisture content of the grain, making environmental conditions more favorable for reproduction. With the high moisture content in grain caused by circulating air at 90% relative humidity and a high flow rate of 1 cubic foot per minute per bushel, the grain became moldy, crusted, and production of rice weevil progeny was limited. When circulated air contained only 30% relative humidity the lower flow rates dried the grain the least and produced the highest number of progeny. With air at 60% relative humidity but lower temperatures of 70° and 60° F., the rate of development and total number of progeny per tube were reduced in both aerated and nonaerated wheat. (MQ 1-18)

An evaluation was made of the effect of moist or dry nitrogen, carbon dioxide, or normal air at 86° F. and at 3 flow rates toward preconditioning 2-week old confused flour beetle adults for susceptibility to fumigants. The treatments in decreasing order of effectiveness were dry nitrogen, moist nitrogen, dry CO₂, moist CO₂, moist air, and dry air. There was no linear correlation between gas flow rate and later fumigant susceptibility. (MQ 1-31)

Twelve hours of exposure to moist or dry carbon dioxide or nitrogen at a flow rate of 100 cc. per minute resulted in the following weight losses of confused flour beetle adults: 20.29% for dry nitrogen, 14.99% for dry carbon dioxide, 8.09% for moist nitrogen, and 3.79% for moist carbon dioxide. Controls with either dry or moist room air lost an average of 3.85% in weight. (MQ 1-31)

A new standard concentration-mortality curve for adult confused flour beetles treated with the fumigant mixture of 80% carbon tetrachloride and 20% carbon disulfide for 24 hours at 80° F. showed that the present laboratory stock culture is somewhat more susceptible than was reported about 40 generations ago. (MQ 1-31)

Information reported under Line Project MQ 1-18 suggests that the typical atmosphere in the natural environment of stored-grain insects may contain a greater amount of carbon dioxide than in normal air. It has also been found that a high level of carbon dioxide exists in culture jars in the laboratory where stored-grain insects are reared. The question arises as to what is a "normal" atmosphere for stored-grain insects. A series of tests is under way with various ratios of oxygen and carbon dioxide to find which will maintain, elevate, or depress respiration and at what point the atmospheric environment becomes detrimental to these insects. Preliminary data indicate that for every 50 percent decrease in oxygen concentration the respiratory quotient is lowered by 23 percent. It is also calculated that in some cases the basal metabolic rate of 2-week old confused flour beetle adults is about 10 times that of an adult human. (MQ 1-31)

A significant condition during nitrogen or carbon dioxide preconditioning of insects is the temporary unavailability of oxygen. Following sublethal preconditioning there is a brief period of elevated respiration for recovery and to repay the oxygen debt incurred. Theoretically this period of high respiration would be when the insects are most susceptible to the action of fumigant gases, so studies were made to learn the extent and duration of elevated respiration. After confused flour beetle adults were held in nitrogen for 2 hours they reached a maximum recovery respiration of 28 percent above normal within 30 minutes after the preconditioning period, and this lasted for 70 minutes. There was a gradual decline in respiration rate during the remaining 4 hours of observation. Insects held

in carbon dioxide for 2 hours reached a maximum respiration of 58% above normal at about 60 minutes after preconditioning, and this lasted for nearly 2 hours. (MQ 1-31)

During the nitrogen preconditioning it was found the gas stream had an oxygen contamination of less than $\frac{1}{2}$ of 1% by volume. Even though the insects were immobile and in anesthesia, it was found they were able to use oxygen even from this minute source, but the average of constant oxygen uptake was about 45% below the normal rate of use. During this time no carbon dioxide production could be detected. (MQ 1-31)

An ecological study is under way to determine the interrelationships and effects of different grain moisture contents and different levels of different kinds of dockage or foreign material in the grain upon the attractiveness of the grain to different kinds of insects and upon the fecundity of various insects when living on the grain. Four series of tests with confused flour beetles and one with red flour beetles have been conducted thus far. One strong trend that is readily apparent is a tremendous increase in number of progeny produced by these insects as the amount of foreign material in the grain is increased. (MQ 0-0-1(CCC))

Research under a contract with the Hebrew University in Jerusalem, Israel, to determine the effects of various environmental factors on the biotic potential of the khapra beetle is progressing in a highly satisfactory manner. Experiments showed that the larvae developed normally at a population density of 100-140 per 3.5 grams of ground wheat. Higher densities resulted in a slower rate of development. Delay in pupation was noted when larvae were reared on food that had been conditioned by having larvae previously live on it to various stages of development. Feeding studies with khapra beetle excrement that had accumulated in food medium indicated a deleterious effect on the rate of development. Further study will attempt to isolate the responsible factor or factors. Feeding khapra beetle larvae on dried larvae of the same species produced pupae that were heavier and adult females that laid more eggs than in the normal control insects. There was no difference in the percentage of eggs that hatched in the two groups. The above effects of this cannibalistic diet extended to the second and third generation beyond the one to which it was fed. (A10-AMS-11(k))

Seven species of fungi and two of bacteria were obtained from samples of beetles in the Tel Aviv, Israel, area. These organisms are apparently carried in the digestive tract of the insects. When the larvae were placed in a clean culture medium they inoculated the medium and as the organisms developed there was a definite increase in temperature of the medium. Use of a fungicide prevented growth of the organisms as well as the consequent rise in temperature. When

sterilized khapra beetle eggs were placed in clean culture medium they developed normally but there was no temperature increase in the medium and the resulting adults appeared not to be as productive as those reared in the presence of the organisms. (A10-AMS-11(k))

2. Insecticide Evaluation. Eighteen numbered candidate compounds were received at Manhattan, Kansas, from the Savannah, Georgia, station and were tested for repellency when applied on grain. None was outstanding in performance. (MQ 1-15)

At Savannah a method was investigated for applying insecticides to be evaluated in laboratory tests as potential protectants to wheat, shelled corn, rough rice, and farmers stock peanuts. Uniform malathion deposits were obtained by applying a liquid formulation of the insecticide to the interior wall of a 1-gallon glass jar containing the commodity, then mixing the insecticide and the commodity through the tumbling action of rotating the jars mechanically. About 83% of the intended deposit was recovered by chemical analysis. The results from this simple method are in sharp contrast to the 30% recovery from application in a twin shell liquid-solid V-type blender that had been procured because it was reported to be specially designed for effective and uniform applications of this nature. (MQ 1-15)

Preliminary tests were conducted at Savannah to determine the comparative effectiveness against rice weevils of malathion, DDVP, Guthion, Substanz 215, and Velsicol W-24 as protectants on wheat. Initial mortality data indicated that malathion and DDVP were the most effective against both the immature and adult insects. Guthion, Substanz 215, and Velsicol W-24 were relatively ineffective. The duration of effectiveness was not tested in this experiment, but some residue data on DDVP indicated that the rate of loss or degradation of the deposit was rapid. (MQ 1-15)

At Tifton, Georgia, 3 candidate grain protectants were tested in the laboratory for immediate toxicity against confused and red flour beetles and rice weevils, when applied on shelled corn. DDVP, Diazinon, and Bayer 29493 were applied at the rates of 5, 10, and 20 p.p.m. and were compared with the standard malathion treatment. All three were equal to or better than malathion. Diazinon was the only one of the three that prevented reproduction of confused flour beetles at all three rates of application. The phase of the test to determine the duration of effectiveness of the deposits is still in progress. (MQ 1-15)

A proportionate share of the cross-commodity insecticide evaluation work at Savannah, Georgia, has been charged to this area. Although

most of the work is directly applicable, it is not feasible to report only certain portions here or to include all the information under each commodity area. Therefore the entire report is included in Area 13.

3. Insecticidal Control. A wettable-powder formulation of malathion seems to be more effective than the emulsion treatment on the basis of bioassay tests and the occurrence of natural populations in treated shelled corn at Watseka, Illinois. Chemical analyses of the deposits on the corn failed to show any differences between the two formulations. In bioassay tests, malathion-treated corn from aerated bins produced lower overall mortality to test insects than did the treated corn from nonaerated bins. Surface samples of corn produced low mortality whether from aerated or nonaerated bins. Mortalities were higher from the nonaerated bins when corn samples were taken at the 4- to 5-foot or the 11- to 12-foot levels. When supplemental surface sprays of malathion were applied to treated, nonaerated bins of corn there was a lower natural insect population and increased mortality in bioassay tests with samples of corn taken from the surface.
(MQ 0-0-1(CCC))

Twelve fumigations have been conducted in the series to study the behavior of liquid fumigants in 3,250-bushel bins with and without aeration systems. Although certain trends seem to be showing up, no definite conclusions can be reached until the entire series of 20 fumigations is completed.
(MQ 0-0-1(CCC))

Under a research contract with the Auburn University Agricultural Experiment Station a study is being made to determine the nature and extent of insect damage to corn in the Southern states at time of harvest and during storage, and to assess the effectiveness of insect control measures as now used for preventing such damage. The study is being made on the 1962 crop in Georgia, Alabama, and Mississippi. Ten species of stored-product insects were found infesting corn at the time of harvest. The predominant ones were the rice weevil, square-necked grain beetle, and Angoumois grain moth. These three were also the most predominant after 6 months of storage. Sixteen insects per pint of shelled corn were found in Georgia and Alabama and 25.2 in Mississippi at the beginning of storage in October. The average moisture content of the corn at that time was 13.2 percent. At the time of harvest the average insect damage in the 3 states was 12.2 percent. In storage the damage had risen to 14.0 percent in January and 19.2 percent in April. About 88 percent of the corn in Alabama is stored on the ear and 12 percent is shelled. Twelve percent of the ear corn and 25 percent of the shelled corn is fumigated in storage. Protectants are used on 8 percent of the ear corn and 13 percent of the shelled corn.
(MQ 1-30(C))

4. Nonchemical Control. Laboratory tests have been initiated in the preliminary phase of a thorough study of inert dusts as potential protective treatments for grain. Major phases of the research include a study of the effectiveness against stored-grain insects of different types of inert dusts with specific physical properties; the influence of grain temperature and moisture content, as well as type of grain, on the immediate and long-term effectiveness of inert dusts against stored-grain insects; and the relative susceptibility of the major kinds of stored-grain insects to inert dusts. Preliminary results confirm that certain inert dusts produce a high initial mortality of some kinds of insects at the time of treatment, and also a high degree of immediate control over the production of progeny. (MQ 1-15)

One approach to the dual objective of preventing insect damage to corn and of reducing the use of pesticides lies in the development of insect-resistant varieties as hybrids. A series of 43 hybrid corns harvested from variety trials at the Coastal Plain Experiment Station, Tifton, Georgia, was rated for resistance to rice weevil attack during storage, on the basis of the number of progeny able to develop during a 90-day test period. The fewest number of progeny produced was 138 in Greenwood 18, and the largest was 1,426 in PAG 750, the most susceptible of the 43 varieties. Preliminary evaluations of resistance to rice-weevil attack were also made on 646 test lines being worked with by the Cereal Crops Research Branch, ARS. A high percentage of samples showed more resistance than did the hybrids now being grown. Rice weevils were apparently unable to feed or develop at all on some of the selections in which there were no progeny at the end of 90 days. (MQ 1-15)

A PL 480 project has recently been initiated by the Direzione Generale dell' Alimentazione of the Ministry of Agriculture and Forests, Rome, Italy, to study insect infestation of spaghetti, macaroni, noodles, and other pastas, and to find ways of preventing such infestation. It is too early to report any experimental results, but a complete survey of the literature has been made. Also about 375 pasta factories were visited to make preliminary observations and find cooperators for work to be done later. (E15-AMS-9(a))

Observations are being made in 4 quonsets of shelled corn where the aeration system pulls air down through the corn and in 4 where the air is pushed up through the corn, to determine whether the two air-flow patterns may vary in their effect on insect populations in the bins. At Watseka, Illinois, there were fewer insects where the air was pushed through the corn. This confirms preliminary observations made at Watseka last year. But in 4 bins at Ellis and 2 at Crescent City, Illinois, there was no apparent difference in the insect populations in the corn aerated by the 2 methods. Observations are continuing to obtain more conclusive information about the effects of these 2 systems on insect populations. (MQ 0-0-1(CCC))

The vertical aeration ducts used in 3,250-bushel bins at ASCS bin-sites have been helpful in holding down insect populations in stored shelled corn. During cooler months, however, insects have been found to congregate near the floor of the bins, below the level of the duct, sometimes in fairly large numbers. Apparently the influence of the aeration duct may not extend to the floor level of the bin, leaving the grain warmer and with a higher moisture content, both conditions favorable for insect development. Comparative observations in bins with horizontal aeration ducts have shown that the corn was cooled more evenly and fewer insects were present. (MQ 0-0-1(CCC))

5. Toxicology. The concluding series of tests in a research contract with the University of Georgia was to determine whether there was any difference in the effects of ethylene dibromide (EDB) on poultry when the compound was administered as the fumigant residue on oats fed to the hens or when it was introduced directly into the birds' crops as was done during the main body of the research study previously reported. No significant differences were found between these methods of administration. For experimental purposes the direct introduction of the compound is to be preferred because of the easier and more precise control over dosage rates. By either method, it was found that 0.5 mg. of EDB per bird per day, equivalent to 5 p.p.m. in the total diet, fed for a period of 12 weeks caused a reduction in egg weight. The reduction was greater as the dosage rate of EDB was increased. The rate of egg production was not affected by 40 p.p.m. of EDB in the diet, but 80 p.p.m. caused a significant drop and 160 p.p.m. stopped production completely within 7 weeks. At 80 p.p.m. the EDB had no apparent effect on feed consumption, body weight, or mortality of the hens. (MQ 1-8(C))

A PL 480 research project at Hebrew University in Rehovot, Israel, is investigating the effect of ethylene dibromide (EDB) fumigated feeds on farm animals. Of the animals tested thus far, laying hens are the most susceptible to the toxic action of EDB. Rats and cockerels were not apparently affected by 200 p.p.m. of EDB in the diet, as far as growth, feed consumption, sexual development, and general health were concerned. Feeding 2 to 3 mg. of EDB per kg. of body weight daily to milk cows, mature cows, calves, and pigs caused no observable effects. Calves a few days old were seriously affected by feeding of 10 mg. of EDB per kg. of body weight daily and died after a few weeks. At 40 mg. per kg. daily the treatment was lethal after only 2 days. The main symptom was pneumonia. EDB added to artificial rumen was recovered unchanged after 25 hours, indicating that it is probably not decomposed in rumen of cattle. The bromine content of blood was elevated by feeding EDB. High bromine levels were found in the organs of poisoned animals. Acute poisoning of rats by EDB caused biochemical changes similar to those induced by carbon tetrachloride. Supplemental studies are being made on the sorbtion and retention of

EDB by various feed products, and on the attempt to develop a simple, rapid method of detection for EDB residues in grain or feed.
(A10-AMS-4(a))

6. Insecticide Residue Analysis. As with insecticide evaluation, the insecticide residue analysis work at Savannah, Georgia, of a cross-commodity nature is reported in Area 13.

A PL 480 research project by the Istituto Superiore di Sanita in Rome, Italy, became effective in 1963 to study in further detail the fate of the residues of several materials when applied as wheat protectants, but it is too early for any results to be reported.
(E15-AMS-8(a))

7. Insect-Resistant Packaging. A part of the cross-commodity packaging work at Savannah, Georgia, has been charged to this area. Although much of the work is directly applicable to grain and to cereal products, it is not feasible to report only certain portions here or to include all the information under each commodity area. The entire report is included in Area 13.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation.

- Baker, Doris. 1962. Fatty Acid Composition of Oil from Damaged Corn and Wheat. Cereal Chemistry, Amer. Assoc. of Cereal Chemists, Vol. 39, No. 5, September 1962. (MQ 3-18)
- Hart, J., and Golumbic, C. 1962. Comparison of Basic Methods of Moisture Determination in Seed. Proceedings of the International Seed Testing Association, Vol. 27, pp. 907-991. (MQ 3-23)
- Kingsolver, C. H., Yeatman, J. N., Boller, R. A., and Thompson, J. A. 1963. Backgrounds and Artificial Lighting for Standardized Grain Inspection. Marketing Research Report No. 606. (MQ 3-30)
- Schroeder, H. W., and Christensen, J. J. 1963. Factors Affecting Resistance of Wheat to Scab Caused by Gibberella zeae. Phytopathology, Vol. 53, No. 7, pp. 831-838. (MQ 3-3)

Prevention of Insect Infestation.

- Fuller, H. L., and Morris, G. K. 1963. The Comparative Toxicity of Ethylene Dibromide When Fed as Fumigated Grain and When Administered in Single Daily Doses. Poultry Science 42(2): 508-514. (MQ 1-8(C))
- Morris, George K., and Fuller, Henry L. 1963. Effect of Ethylene Dibromide in the Diet on the Growth of Chicks. Poultry Science 42(1): 15-20. (MQ 1-8(C))
- Stored-Product Insects Branch. 1962. Insects in Farm-Stored Wheat--How to Control Them. USDA, Leaflet No. 345, 8 pp., Revised October 1962. (MQ 1)
- Stored-Product Insects Branch. 1962. Method and Equipment for Bulk Treatment of Grain Against Insects. USDA, Marketing Bull. No. 20, 7 pp. (BS 1-34)
- Stored-Product Insects Branch. 1963. Sampling Methods for Determining Insect Populations in Stored Grain. USDA, AMS-497, 2 pp. (MQ 1)

AREA 4a

RICE - MARKET QUALITY

Problem.

Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation during storage either as rough or milled rice. Safe storage of rice for extended periods is a problem of immediate concern to military and civilian defense agencies. To maintain the quality of this product, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products in the marketing channels and more equitable prices to all concerned, new and improved methods and techniques for measuring quality factors need to be developed for use in the inspection, grading, and standardization procedures. There is urgent need for more effective methods for preventing insect damage and contamination during storage, handling, processing, and transportation. The need is critical for the development of effective pesticides and application methods that can be used in the marketing channels without leaving objectionable residues. Even more desirable is the development, wherever possible, of effective preventive and control measures utilizing biological, physical, or mechanical means that would completely eliminate the need for pesticidal chemicals.

USDA PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station.

A grant with the Department of Plant Chemistry, Valencia, Spain, provides for a study on objective methods for measuring market quality of rice. Its duration is for 4 years, 1960-1964, and involves P. L. 480 funds with a \$19,390 equivalent in Spanish pesetas.

The Federal scientific effort in this area totals 2 professional man-years: quality evaluation 1.0, quality maintenance in handling and packaging 0.5 and quality maintenance in storage 0.5.

Line Project MQ 2-7, "Cause and development of control of micro-biological, chemical, and physical deterioration of rough rice in relation to off-farm conditioning, handling, and storage in the South Central states," was recently revised.

The Department also has a continuing long term program involving entomologists engaged in applied research on the control of insects attacking stored rice. For several years the research has been conducted at Houston, Texas, in cooperation with various industry groups, the Agricultural Stabilization and Conservation Service, the Field Crops and Animal Products Branch, MQRD, AMS, and the Texas Agricultural Experiment Station. Toward the end of the reporting period the work was relocated at Fresno, California, as part of a Branch action to consolidate several small field stations. This will permit more effective utilization of manpower and equipment.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has cross-commodity application. Although much of the work on insecticide evaluation, insecticide residue analysis, and insect-resistant packaging has a direct relation to stored rice, only a proportionate share of that effort has been charged to this area.

The Federal scientific effort devoted to entomological research in this area totals 3.5 professional man-years divided as follows: insecticidal control 0.2 and nonchemical control 1.8 at Houston; insecticide evaluation 0.4, insecticide residue analysis 0.4, and insect-resistant packaging 0.3 at Savannah; and program leadership 0.4 at Hyattsville, Maryland.

Line Project MQ 1-3, "Development of improved procedures for fumigating milled rice in storage," was discontinued.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Long-Grain Milled Rice. An improved apparatus for the alkali test which was developed for differentiating long-grain varieties of milled rice was tested on new varieties. A physical method for differentiating certain newly developed long-grain varieties of milled rice was developed. A rapid light reflectance method for determining degree of parboiling in rice is now being tested.
(MQ 3-12)

2. Objective Measurements for Determining the Degree of Milling of Rice. Additional tests of the rice photometer to determine more suitable wavelengths for measuring the degree of milling of parboiled rice were made. The highest correlation between rice photometer readings and official rice graders' ratings were obtained with the ratio T859 mμ/T660 mμ.
(MQ 3-16)

3. Chemical Indicators of Quality. This P. L. 480 project in Spain confirmed the relationship between amylopectin and quality reported previously and supports the view that molecular weight of amylopectin has an influence on the behavior of rice being cooked. A high amylopectin molecular weight provides the starch granule with an elasticity of structure and resistance to breakage during swelling. Among aged samples, in general, long-grain rices require longer cooking times than short-grain rices; this tendency was also observed when studying the fresh rice samples.
(E25-AMS-1(a))

Total protein does not constitute an index of quality of rice although it has some relationship to quality the heterogeneity of rice grain endosperm was confirmed, particularly that the outer layers are richer in protein than the inner ones. A new rice quality test was based on this fact.

B. Quality maintenance in handling and packaging

The effects of infrared drying of rice and treatment of rice with preservatives have been verified by additional experimentation. Rough rice (air-dried and infrared-dried) with an initial moisture content of 12.4 percent was stored in an atmosphere with a

relative humidity of 85 percent at 30° C. for 33 days and sampled at intervals of 3-7 days. Air was circulated continuously in the storage chamber (continuous aeration). Infrared-dried rice remained at a lower moisture content throughout the experiment. Storage mold infestation of infrared-dried rice treated with preservative was reduced after 3 weeks storage in 100 percent relative humidity at 30° C. in comparison to similar samples that were not treated. An experiment is being designed to measure the grain temperature of rough rice stored at various relative humidities. This will be related to change in fungal flora of the rice as determined by plating techniques.

(MQ 2-7 (Rev.))

C. Quality maintenance in storage

1. Heat Damage of Rice. This research project covers the cause and prevention of heat damage in rough rice in relation to off-farm conditioning, handling, and storage in the South-Central States. The free amino acids extracted from rice discolored as a result of infestation by Fusarium chlamydosporium are being investigated and compared with the free amino acids from non-infested rice. A technique involving two dimensional multi-chromatography of extracts purified by the use of a strong cation resin column has resulted in the separation of 22 ninhydrin reactive compounds from infested rice as compared with 17 from noninfested rice. Quantitative differences are also obvious from the inspection of the chromatograms. The presence of furfural or hydromethyl-furfuraldehyde (compounds associated with the Maillard reaction) have not been demonstrated in either extracts from the discolored rice or the cultural filtrates.

(MQ 2-76)

2. Damage and Off-Color in Rough Rice. This new study is concerned with the cause and prevention of damage and off-color in rough rice in relation to off-farm conditioning, handling, and storage in the South-Central States. Inoculation experiments with Aspergillus spp. have been temporarily discontinued. Handling grain heavily infested with these species contaminated the laboratory to such a degree that numerous experiments had to be discarded. Rhizoctonia spp. isolated from Belle Patna rice is being investigated to see if it is a cause of the discoloration being reported in rice by industry. The study will include Bluebonnet 50 to determine if the reported varietal susceptibility of Belle Patna is valid.

(MQ 2-77)

D. Prevention of insect infestation

1. Insecticide Evaluation. A part of the program on insecticide evaluation at Savannah, Georgia, has been charged to rice. Although much of this research is directly applicable, it is not feasible to report only certain portions here, or to include all the information under each of the several appropriate commodity areas. Therefore the entire report is included in Area 13, "Insect Control in Marketing Channels - Cross Commodity."

2. Insecticidal Control. The remainder of the tests were concluded in the series of experiments planned to develop improved procedures for fumigating milled rice in storage. Suitable dosage levels and methods of application were determined for several fumigants for bulk and bagged milled rice and the line project was terminated.

(MQ 1-3)

3. Insecticide Residue Analysis. The overall chemical analytical program at Savannah, Georgia, is reported in Area 13.

4. Nonchemical Control. Laboratory tests have shown that the common internal feeding insects of rough rice can be killed by infra-red radiation at temperatures that are harmless to the rice. Early data suggested that the reproduction of rice weevils and lesser grain borers subjected to sub-lethal radiation was severely limited. An intensive study of the Angoumois grain moth, however, indicate that reproduction of this species was not seriously affected by exposure to infra-red radiation at sub-lethal levels.

(MQ 1-9)

A large scale test was conducted with 3 chemically inert dusts of the silica gel type as protective treatments for rice to prevent insect infestation. They continued to give satisfactory protection until it was necessary to move the rice. At that time they added considerably to the dust problem during the handling of the rice. This could be a serious deterrent to the commercial acceptance of inert dust treatments for grain. The dust did not adversely affect the milling qualities or the germination of the rice.

(MQ 1-19)

5. Insect-Resistant Packaging. These studies at Savannah, Georgia, as with those on insecticide evaluation and insecticide residue analysis, are reported under Area 13.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Johnson, R. M., and Neustadt, Morris H. 1962. An improved apparatus for the alkali test for differentiating long-grain varieties of milled rice. The Rice Journal 64(10): 8-9.

(MQ 3-12)

Johnson, Robert M. 1963. A physical method for differentiating certain long-grain milled rice varieties. Cereal Science Today 8(3): 84-90.

(MQ 3-12)

Primo, E., Casas, A., Barber, S., y Barber, C. Benedito de. 1962. Factores de calidad del arroz. VII. Ensayos selectivos basados en el envejecimiento: Propiedades organolepticas y fisicoquimicas del grano. Publicado en la Revista de Agroquimica y Tecnologia de Alimentos Vol. 2 n° 3, julio-septre. 1/

Primo, E., Casas, A., Barber, S., y Barber, C. Benedito de. 1962. Factores de calidad del arroz. VIII. Caracteristicas fisico-quimicas del almidon y de sus fracciones Su variacion con el envejecimiento. Publicado en la Revista de Agroquimica y Tecnologia de Alimentos Vol. 2, n° 4, oct.-dic. 1/

Primo, E., Casas, A., Barber, S., Barber, C. Benedito de, Alberola, J., y Pinaga, F. 1962. Factores de calidad del arroz. IX. Influencia de las fracciones proteicas sobre la calidad de coccion. Publicado en la Revista de Agroquimica y Tecnologia de Alimentos. Vol. 2, n° 4, Oct.-dic. 1/

Primo, E., Casas, A., Barber, S., y Barber, C. Benedito de. 1963. Factores de calidad del arroz. IV. Distribution del nitrogeno en el endospermo. Publicado en la Revista de Agroquimica y Tecnologia de Alimentos, Vol. 3, n° 1, enero-marzo. 1/

Quality Maintenance in Storage

Schroeder, Harry W., and Halick, John V. 1963. Effects of moisture content, humidity, and length of storage on maintenance of quality in rough rice. Marketing Research Report #598.

(MQ 2-77)

Schroeder, Harry W. 1963. The relation between storage molds and damage in high-moisture rice in aerated storage. Phytopathology, July, pp. 804-808.

(MQ 2-77)

1/ These publications resulted from work under P. L. 480 grant E25-AMS-1(a).

- Schroeder, Harry W. 1963. Changes in the fungus flora of rough rice after flooding with saline water by Hurricane Carla. Plant Disease Reporter 47: 118. (MQ 2-77)
- Schroeder, Harry W. 1963. Orange stain, a storage disease of rice caused by penicillium puberulum. Phytopathology, Vol. 53, No. 7, pp. 843-845. (MQ 2-77)
- Schroeder, Harry W. 1963. Effect of the growth of fungi on head rice yields. Proc. of Rice Technical Working Group, February 21-22, 1963, Houston, Texas, p. 31, March. (MQ 2-77)
- Schroeder, Harry W. 1963. Two types of rice kernel discoloration caused by fungi. Published in Proc. of Rice Technical Working Group, February 21-22, 1963, Houston, Texas, pp. 30-31, March. (MQ 2-77)

Prevention of Insect Infestation

- Tilton, Elvin W., and Cogburn, Robert R. 1963. Field tests of phosphine gas for fumigation of rice. Proceedings Rice Technical Working Group, February 21-22, 1963, Houston, Texas, p. 29, March 1963. (MQ 1-3)
- Cogburn, Robert R., and Tilton, Elvin W. 1963. Using phosphine to protect stored grain from insects. Published in Agricultural Marketing, Vol. 8, No. 3, p. 3, March 1963. (MQ 1-3)
- Tilton, Elvin W., and Schroeder, Harry W. 1963. Infrared heaters (nonchemical) may protect stored grain from insect damage. Published in Agricultural Marketing, Vol. 8, No. 1, January 1963. (MQ 1-9)

AREA 4b

FEED AND SEED - MARKET QUALITY

Problem.

Feed and seed may suffer damage or deterioration in quality from insect attacks, from microorganisms, and from normal metabolic changes. Insect infestations are a major problem with feed and do much damage both to the individual components and to the mixed product. Seeds are also subject to insect damage. Quality determination of seed is essential to modern agriculture and orderly marketing. Important quality factors include genetic purity, germination, vigor, weed-seed content, disease-organism infestation, and mechanical purity. Methods of determining seed quality are outdated, requiring much time, tedious work, and 1 to 6 weeks for completion of germination tests. Because seed is an important item in interstate and international channels of commerce, methods of testing for quality should permit duplication of results by laboratories in different states and countries. Stored seed is subject to deterioration with respect to germination and vigor. Deterioration caused by fungi, bacteria, and metabolic changes within the seed is influenced by storage temperature, relative humidity, gases, and time in storage. Research is needed to learn the biochemical changes that take place during seed germination, to mechanize and simplify the methods of testing seeds, and to improve the storage life of seeds.

Development of rapid, simple tests for determining the quality of feeds is essential as new sources of proteins, vitamins, and other additives are mixed with animal feeds. More information is also needed so that feedstuffs can be stored with a minimum of loss in quality.

USDA PROGRAM

The Department has a continuing long-term program involving chemists, botanists, seed technologists, plant physiologists, and plant pathologists engaged in both basic and applied research on quality evaluation and quality maintenance of seed. This research is

conducted at Beltsville, Maryland; Raleigh, North Carolina; and at College Station, Texas, and by research contract with experiment stations of Mississippi, Iowa, and Oregon.

A grant with Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves P. L. 480 funds with a \$103,785 equivalent in Israeli pounds.

A P.L. 480 grant with Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. Its duration is 5 years, 1962-1967, and involves \$31,016 equivalent in Brazilian cruzeiro.

A P.L. 480 grant with Rijksproefstation voor Zaadcontrole, Bonnenhaven 1, Wageningen, The Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. This project has been approved but work will not be started until about January 1, 1964. The duration of the project is for 5 years and the total grant is the equivalent of \$55,777.

The Federal scientific effort devoted to research in this area totals 8.5 professional man-years, of which 3.5 man-years are by research contract.

Work terminated during the period included studies on classification of seedlings produced in laboratory germination tests from seeds of southern crops such as cotton, peanuts, velvet beans, soybeans, and lupines (MQ 3-19) and seed blending (MQ 3-8(c)).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Seed Blending. Seventeen devices were tested for performance in blending seed of similar and dissimilar composition. The principal crop seeds used were soybean, birdsfoot trefoil, sorghum, fescue, and oats. Four batch blenders were evaluated: Nauta mixer, twin shell mixer, double cone mixer, and a rotating drum mixer with the drum mounted diagonally on a horizontal axis. All four blenders gave good results but the size of the lot blended would be limited by the capacity of the blender.

Several types of continuous blenders and devices were used. These made use of columns of baffles, columns of funnels and cones, rotating cylinders, revolving distributors, and commercial seed dividers. Of these devices, the Boerner seed divider produced the best results. One unit designed and constructed under the project provided a uniform and systematic placement of each component into a container. The individual particles and components assumed random arrangement within these small subunits. The results were not entirely satisfactory, but showed considerable promise. This project has been terminated.

(MQ 3-8(c))

2. Seedling Classification and Seed Dormancy. A study of seedling classification of cotton showed that the primary difficulty was infestation of the young seedlings with fungi. Treatment of the seeds in baths with ultrasonic radiation to remove the mold spores had little effect on seedling diseases. Treatment of the seeds with the fungicide, Ceresan M, significantly reduced seedling infection and increased the percentage of normal seedlings. It is recommended that in routine testing of cotton seeds, two parallel tests be made: one test on seeds without any treatment and another on seeds treated with an effective fungicide. A study to determine the correlation between actual germination and electrical conductivity of water in which seeds had been soaked did not yield encouraging results.

Texas needlegrass seeds are extremely dormant and possess enveloping structures that interfere with the penetration of water. Also, a relatively high percentage of the true seeds are too immature to germinate. A study of this species showed that a very delicate balance of moisture and aeration is necessary for reasonably good germination. The most satisfactory method found to overcome dormancy consisted in orienting the seeds on the substratum in such a way that only the bases of the seeds were in contact with the moist substratum and the apical end extended into the air. Several temperature combinations gave satisfactory germination when the seeds were oriented as indicated above. When the glumes were removed the seeds germinated readily under a variety of conditions.

(MQ 3-19)

3. Mechanization of Purity Analysis. Work under this project, begun last year, has resulted in the designing and construction of models of several laboratory size machines which will reduce

the time and tediousness of certain operations in making purity analyses of seeds. The equipment has been tested by unbiased workers and demonstrated before a national convention of official and commercial seed technologists. Two machines have been approved for routine laboratory use and construction specifications and plans will be made available at an early date. These include (a) a vibrator separator which will separate many kinds of seeds much like the gravity machines in commercial use and (b) an examination station for seeds treated with poisonous chemicals. The latter machine permits the seed to move past a viewing point on a movable belt, controlled by foot switch, and be viewed through a transparent plastic window. Rejected particles are removed with vacuum pickup needles. Development of other machines is proceeding satisfactorily.

(MQ 3-21(c))

4. Rapid Electrical Methods for Determining Moisture Content of Seeds. A meter has been developed adapting a commercial electronic moisture meter for determining moisture in light and chaffy seeds. The meter is being tried on Kentucky bluegrass, perennial ryegrass and other grass seeds. It shows promise but will require much more testing.

(MQ 3-23)

5. Seed Metabolism. Procedures were developed for isolation of RNA and DNA from peanut cotyledons at various stages of germination. These nucleic acids were studied by means of column chromatography and density gradient fractionations as well as by base ratio analyses. A major shift in the nature of the high molecular weight RNA component was noted between the first and second day of germination. Similar experiments with P^{32} -labeled nucleic acid demonstrated that the germinating cotyledon actively synthesizes all nucleic acid components. Studies on enzyme development with germination demonstrated that enzyme formation in the cotyledon proceeds in the absence of the embryo and proceeds even when embryo germination is completely inhibited.

(MQ 3-32)

6. Determining the Purity of Certain Grass Seeds. Acetone, ethyl alcohol, methanol, hexane, and carbon tetrachloride were evaluated as media for separating pure seed and inert matter of dallisgrass seed and bahiagrass seed on the basis of specific gravity. Germination tests were made to determine the effects of these solvents on germination. None of the compounds had a significant effect on germination of bahiagrass seed at the 99

percent confidence level. Ethyl alcohol, methanol, and acetone significantly lowered the germination of dallisgrass but the other solvents did not. Of several liquids tested for separating seeds by specific gravity, ethanol and methanol were significantly better. Surface tension, especially with kerosene, was found to be an important factor.

(MQ 3-39)

7. Hay Moisture. This new project covers research to develop an accurate and rapid method for determining the moisture content of grass and legume hay for use in routine testing. Twenty-six samples of alfalfa hay were measured by a compression device using a newly-designed large sample holder. An electrode plate designed to fit this 5-inch cylinder sample holder consisted of a dish with four stainless steel pins mounted 2 inches apart on a 1.414-inch radius from center of dish. The holder is capable of holding from 250 to 350 grams of dry hay. The moisture content of these samples varied from 11.9 to 29.0 percent moisture as determined by a forced air oven. The correlation between the meter reading and oven was very good (0.97) for these 26 samples. The standard error of estimate was ± 1.03 percent.

(MQ 3-41)

8. Development of Seed Germinator. Research was started to develop an automatic alternating temperature seed germinator for use in routine testing. The experimental unit was equipped with thermistor activated temperature controllers in order to obtain closer control of temperatures than could be obtained with gas-filled bulb thermostats. Any two temperatures desired from 10° C. to 35° C. can be selected simply by positioning a rotary switch. In performance studies, temperatures were controlled to $\pm 0.5^\circ$ C. Relative humidity was maintained above 95 percent except for a brief period when switching from the high to low temperature cycle. The temperature changes from low to high are made in approximately 40 minutes and from high to low in approximately 1 hour. The problem of obtaining more uniform lighting in the box will be under study the coming year. Germination tests indicate lighting is sufficient but distribution is poor and trays must be rotated daily.

(MQ 3-48)

9. Cereal Grains and Feeds. Research aimed at the development of a rapid, simple test for protein nutritive value of cereal grains and feeds is being conducted by Technion Research and Development Foundation, Ltd., Haifa, Israel, under a P.L. 480

grant. Soybeans, rice, wheat, peanuts, and cottonseed meal were placed in storage under different conditions of temperature and humidity. Any successful method must measure quality of commodities after storage under both favorable and unfavorable conditions. The nature of the project makes it possible to study both quality maintenance and quality measurement. Analysis of all foods has been carried out according to AOAC methods and by additional methods, including feeding experiments with rats and miscellaneous chemical and physical tests.

Twelve amino acids were determined microbiologically in the various stored commodities and enzymatic releases of methionine, lysine and tryptophane were determined in eight foods. Optimal conditions for determining glutamic acid decarboxylase activity in soybeans, chickpeas, wheat, and rice have been established. A method, capable of standardization, for protein dispersion from soybeans, peanut meal, cottonseed, and chickpeas containing globulin-like proteins has been developed. Some difficulty has been experienced in obtaining random groups of uniformly developing rats for the feeding experiments but the variation has been reduced by selection of mothers for several characteristics and by using rats whose ages differ by no more than 2 days.

(A10-AMS-7(a))

10. Moisture Levels for Germination. A P.L. 480 grant was made to the Instituto Biologico, Sao Paulo, Brazil, for the study of substrate moisture levels for germination testing of agricultural seeds. The principal accomplishments reported by the Instituto Biologico are: (a) The optimum moisture level for germination is not always optimum for future growth of the seedling, (b) seedling classification must be taken into consideration in the study of moisture relationships, (c) water was found to be dependent on weight of seeds of a similar kind and not on the number of seeds involved, (d) a procedure was developed for holding soil as a substratum at three different uniform moisture levels, thus providing a basis for evaluating tests made on other substrates.

(S3-AMS-2(a))

11. Health Condition of Seeds. A P.L. 480 grant with Rijksproefstation voor Zaadcontrole, Binnenhaven 1, Wageningen, The Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. This project has been approved but work will not be started until about January 1964.

(E19-AMS-11(a))

B. Quality maintenance in storage

1. Quality Maintenance of Corn in Storage. The results of these studies indicate that corn seed with a moisture content of 8 percent or less, can be stored at 68° F. and below at levels of oxygen ranging from 0 to 100 percent, without a severe reduction in germination or growth of seedlings. Methods of chemical analysis were adapted to study injuries on very dry corn in storage caused by oxygen.

In general, peroxide formation was not directly related to the storage life and vigor of the seed. Assays for carotenoids showed a decline of pigments during storage which apparently was correlated with the amount of oxygen in the storage atmosphere. This loss of pigment appeared to be one of oxidation and was not correlated with seed moisture. No significant variation was revealed between the total fat content of seeds of different moisture contents stored at different oxygen levels. Results of phosphorous analysis were disappointing due to lack of suitable methods for analyzing the small fractions involved. Studies of conductivity of seed leachates indicated that results of these tests might be more reliable in the general assessment of stored grain rather than as tests for germination.

Respiration studies of very dry corn revealed extremely low rates of carbon dioxide production. These results and other corroborative evidence could suggest that the carbon dioxide obtained was not the result of enzymatic respiration.

(MQ 2-34)

2. Deterioration of Grass Seed. Year-old seeds of seven kinds of grasses received from seedsmen were plated out on salt-malt extract agar suitable for the growth of storage fungi. Sixteen species of *Aspergillus* were obtained in pure culture and identified. Some of these fungi will be used to inoculate grass seeds that will be stored for several months at 16 combinations of temperature and relative humidity. These seeds will be used to study the progress of infection and pathological histology.

The moisture contents of 38 samples of grass seed harvested in 1962 ranged from 7.94 to 9.51 percent (wet weight basis). Most of these samples were found to be infected by species of *Aspergillus* that are reported to infect grain whose moisture is above 13 percent.

No significant differences were observed between the mold flora of 10 samples of spotted wheat and that of 4 nonspotted (check) samples. Cultures of a number of pathogenic species of *Helminthosporium* and *Fusarium* are being evaluated to determine whether one of them may produce an inhibitory substance that can be used in developing a vigor test for seeds and seedlings.

(MQ 2-62)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Andersen, Alice M. 1962. Effect of gibberellic acid, kinetin-like substance, Ceresan, and phenacridane chloride on the germination of *Panicum ramosum* seeds. Proc. Internat. Seed Test. Assn. 27(3): 730-741. (MQ 3-19)

Hart, Joe R., and Golumbic, Calvin. 1962. A comparison of basic methods for moisture determination in seeds. Proc. Internat. Seed Test. Assn. 27(4): 907-919. (MQ 3-23)

Marcus, A., Feeley, J., and Shannon, L. M. 1963. Preparation and properties of γ -methylene glutamic acid. Arch. Biochem. Biophys. 100, 80. (MQ 3-32)

Marcus, A., and Feeley, J. 1962. Nucleic acid changes in the germinating peanut. Biochem. Biophys. Acta 61, 830. (MQ 3-32)

Marcus, A., and Shannon, L. M. 1962. γ -Methyl- γ -hydroxy- α -ketoglutaric aldolase II. Studies with pyruvate- C^{14} . J. Biol. Chem. 237, 3348. (MQ 3-32)

Shannon, L. M., and Marcus, A. 1962. γ -Methyl- γ -hydroxy- α -ketoglutaric aldolase I. Purification and properties. J. Biol. Chem. 237, 3342. (MQ 3-32)

AREA 5

LIVESTOCK AND MEAT - MARKET QUALITY

Problem.

Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor, and fat content. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of meat are needed. Also needed are more effective methods to minimize shrinkage while maintaining optimum quality, bloom, and shelf-life of the product as it moves through market channels.

USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, and also in part by research contracts with the University of Oklahoma, University of Wisconsin, and the University of Missouri. Research, basic and applied, includes the development of objective methods for evaluating the composition of livestock, carcasses, and meat cuts; the application of ultrasonic techniques to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep; and the use of improved sanitary practices in the merchandising of meat to extend the shelf-life of meats. New techniques for measuring meat tenderness are being developed and evaluated.

A grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on refrigerated meat. Its duration is 4 years, 1963-1967, and involves P.L. 480 funds with a \$44,453.40 equivalent in Finnmarks.

The Federal scientific effort devoted to research in this area totals 3.6 professional man-years of which 2.4 man-years is by research contract. Effort is devoted to objective measurement and evaluation of quality and shelf-life of prepackaged fresh meats. During the report period, work on factors influencing quality in pork (MQ 3-9(c)) was completed. Studies on the influence of bovine age upon meat characteristics and grade (MQ 3-10(c)) were also completed.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Factors Influencing Quality in Pork. The aim of the study was (1) determine within commercially useable limits the effects of fat, age, and carcass weight on flavor, juiciness, tenderness, and aroma of fresh and cured pork products and (2) to develop factors which may be used to establish grade standards for pork cuts.

Marbling and age of the animal were found to be the most important factors associated with flavor, juiciness, and tenderness of loins and fresh hams. Pork cuts were generally acceptable to taste panels if they contained approximately 20 percent intramuscular fat (moisture free basis) or were from animals less than 220 days of age. Differences in the amount of lean present in pork muscle appeared to cause little change in flavor, juiciness, and tenderness of pork muscle. However, an increase in the amount of lean increased the cooking yield.

Color intensity of the rib eye muscle of different loins did not appear to affect flavor, juiciness, and tenderness if these different loins had the same weight or same acidity.

Although flavor, juiciness, and tenderness of commercially-cured hams in the study varied, all appeared to be acceptable to taste panels regardless of animal age, carcass weight, or intramuscular fat content. Bacon became more tender with increasing amounts of intramuscular fat. Flavor and juiciness of bacon from commercial animals showed little difference because of differences in animal age, carcass weight, or intramuscular fat content.

(MQ 3-9(c))

2. Influence of Bovine Age Upon Meat Characteristic and Grade.

The contractor has submitted a final report of the work conducted under this contract. Several publications reporting the results of this research have been published and several other publications are being prepared. Some of the important findings are as follows: Histological results revealed that the primary muscle bundle diameters increased 70 percent by 18 months of age, then increased another 9 percent by 42 months of age. The muscle fibers showed the smallest increase in diameter during the phase of greatest increase in muscle bundle diameter. The amounts of collagenous bundles and elastic fibers are higher in the semi-tendinosis

than the longissimus dorsi muscle in beef. Marbling had a significant effect on the size of the muscle fiber diameter - increasing the fiber size as marbling increased. However, those carcasses possessing a high level of marbling also had a lower percentage of lean. This is also associated with a higher percentage of external and intermuscular fat.

(MQ 3-10(c))

3. Evaluation of Live Animals in Relation to Composition. Data obtained from gamma-ray measurements and analyses of carcass components of swine varying in age and weight were processed and analyzed. Correlations of carcass components - shoulder, belly, loin, and butt - to gamma-ray measurements all gave significant correlations. However, correlations between bellies and shoulders gave the most significant correlations - .663 and .531, respectively.

(MQ 3-34)

4. Measurement of Tenderness. The Slice-Tenderness Evaluator (STE) developed to measure the tenderness in a slice of cooked meat was compared to a commercial testing instrument and with subjective taste panel evaluations. This device has an advantage over others in that the measurements are made on a 0.2-inch thick slice of meat which is typical of a serving of meat.

(MQ 3-34)

5. Odor-Measuring Instrument. A project on the development of an odor-measuring instrument for use in inspection and grading of foods is being conducted in Turkey under a P.L. 480 grant. A bibliography of the following subjects has been made: Olfaction, measurement of odor, methods of combatting odor, and surface tension. The development and construction of the Tanyolac instrument was completed since it detects the presence of odors by measuring the changes in the surface tension of spherically shaped drops of water or mercury when the drop size is kept constant.

(A22-AMS-1(a))

B. Quality maintenance in handling and packaging

Shelf-life of Prepackaged Fresh Meats. A 4-year research contract has been granted to the University of Missouri to study the factors affecting shelf-life of prepackaged fresh meats. Work under the terms of this contract has just been initiated. The main objective of this research is to evaluate under controlled conditions the influence of the various commercial handling methods upon the shelf-life of packaged meat.

(MQ 2-75)

C. Quality maintenance during transportation

Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meat. This is a new P.L. 480 research project in Finland. No report has been received from the contractor but the objective of the work will be to study changes in the properties of meat under refrigeration in atmospheres with added carbon dioxide or nitrogen such as would be encountered when liquid carbon dioxide or nitrogen are used for refrigeration during rail or truck transportation.

(E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Alsmeyer, R. H., Kulwich, R., and Hiner, R. L. 1962. Loin-eye tenderness variations measured by STE. Abstract. Jour. Animal Science 21(11), (Abstract No. 40) 977. (MQ 3-34)

Bray, Robert W. 1962. What will hogs and pork be like in 1970? National Provisioner, May 19, 1962. (MQ 3-9(c))

Carpenter, Z. L., Bray, R. W., Kauffman, R. G., Briskey, E. J., and Weckel, K. G. 1963. Factors influencing quality in pork. A. Histological observations. Jour. Food Science, 28, 4, pp. 467-471. (MQ 3-9(c))

Henrickson, R. L., and Mjoseh, J. H. 1963. Tenderness variation in two bovine muscles. Abstract. Jour. Animal Science, Vol. 22, No. 1, p. 250. (MQ 3-10(c))

Kulwich, R., Decker, R. W., and Alsmeyer, R. H. 1963. Use of slice tenderness evaluation device with pork. Food Tech. 17(2) 83-85. (MQ 3-34)

Tuma, H. J., Henrickson, R. L., Stephens, D. F., and Moore, Ruby. 1962. Influence of marbling and animal age on factors associated with beef quality. Jour. Animal Science, Vol. 21, No. 4. (MQ 3-10(c))

Tuma, H. J., Hendrickson, R. L., Odell, G. V., and Stephens, D. F. 1962. The variation in the physical and chemical characteristics of the Longissimus dorsi muscle from animals differing in age. Jour. Animal Science, 21 848-851. (MQ 3-10(c))

- Venable, J. H. 1963. The histology of muscle. Proc. Meat Tenderness Symposium, Campbell Soup Company, Camden, N. J., Jan. 15, 1963, 9-31. (MQ 3-10(c))
- Venable, J., and Hendrickson, R. L. 1962. A photographic technique for the determination of percent area of elastic fibers and collagenous bundles in muscle 1, 2, 3. Proc. 15th Reciprocal Meat Conference, June 13-15, 255-259. (MQ 3-10(c))

AREA 6

OILSEEDS AND PEANUTS - MARKET QUALITY

Problem.

Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus damage and contamination, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various species of insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization procedures.

The demonstrated development of resistance to pyrethrum and malathion by stored-peanut insects, either in the laboratory or in the field, jeopardizes the future of the treatments now used for protecting stored farmers' stock peanuts. This indicates the urgency for developing new preventive or control measures, because it is impossible to predict how soon current measures may become ineffective. There is also a need to study the nature of insect problems in peanut shelling plants and to develop effective measures for preventing insect infestation and damage at this stage of handling.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods for quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C.; research on peanuts is done at Raleigh, North Carolina, in cooperation with the North Carolina State College and Federal-State Inspection Service, at Albany, Georgia, in cooperation with the University of Georgia, and also by research contract with Texas A & M, College Station, Texas.

A P.L. 480 grant with the College of Agriculture, Olsztyn, Poland, provides for a study of storage changes in flaxseed. Its duration is 4 years, 1960-1964, and involves P.L. 480 funds with an \$18,127 equivalent in Polish zlotys.

A P.L. 480 grant with Università Di Firenze, Institute Of Industrie Agrone Il Direttore, Florence, Italy, provides for a study of the effect of different types of containers on long-time bulk storage on the quality of vegetable oils, and to examine the natural antioxidants and their effect upon the quality of the oil. Its duration is 5 years, 1962-1967, and involves P.L. 480 funds with an \$26,344.61 equivalent in Italian liras.

The Federal scientific effort devoted to research in this area totals 5.3 professional man-years. Of this number 4.3 are devoted to quality evaluation and 1.0 to quality maintenance.

The Department also has a continuing long-term program at Tifton and Savannah, Georgia, involving entomologists engaged in basic and applied research on problems of insect infestation, damage, and contamination of peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service of this Department, growers' cooperative associations, and various industry groups.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has cross-commodity application. Much of the work has a direct or indirect relation to oilseeds and peanuts but only a part of the effort has been charged to Area 3.

The Federal scientific effort devoted to entomological research totals 3.7 man-years divided as follows: Insecticide evaluation 0.2, insecticidal control 0.2, and nonchemical control 0.6 at Tifton; insecticide evaluation 0.6, insecticide residue analysis 0.5, and nonchemical control 1.2 at Savannah; and program supervision 0.4 at Hyattsville, Maryland.

Line Project MQ 1-14, "Evaluation of protective sprays and dusts for preventing insect damage to stored farmers stock peanuts," was discontinued.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. The pneumatic samplers for peanuts, developed under this project, have been installed at 165 buying points in the Southeastern peanut growing area.

Mechanization of the sampling, shelling, splitting, and sizing operations in the grading process for farmers' stock peanuts has enabled the use of larger, more representative samples. The size of the grading sample is still limited, however, due to the amount of time required to hand-clean the samples for foreign-material determinations. An improved model of the sample cleaner which was tested in 1962 has been constructed and is being tested by the Federal-State Inspection Service during the 1963 marketing season. A complete set of working drawings on the machine have been prepared.

Peanut kernels are screened during the grading operation and the percent of kernels that ride certain screens is an important grade factor. Studies have shown that the moisture content of the kernels as well as the method of curing them will have an effect upon this percentage. Slow drying during the curing process and high moisture content at time of screening tend to increase the percentage while rapid drying and low moisture contents decrease it.

It is important to note that peanut kernels are not symmetrical and the screening process measures the shortest dimension of the kernel, not its size or volume. Density measurements have indicated that although rapid drying decreases the shortest dimension of the peanut kernel it also increases the volume or size of the kernel.

(MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Studies have shown that off-flavors are produced in peanuts when they are cured in the absence of oxygen. Peanuts cured in atmospheres of nitrogen at 100° F. have off-flavors quite similar to off-flavors produced in peanuts cured in normal atmospheres at 125° F. Respiration studies have been made on mature and immature peanuts curing at 95° F. and 125° F. These studies indicate that anaerobic respiration occurs under the same conditions that produce off-flavors in peanuts. The quantity of CO₂ evolved by

anaerobic pathways during a given curing treatment appears to closely parallel the amount of off-flavor produced in peanuts by that curing treatment.

Samples of peanuts cured by three different methods and harvested on three different dates were submitted to three leading manufacturers of peanut butter for taste panel evaluations. The results of the tests indicate that time of harvest as well as curing treatment had considerable influence on the flavor of peanut butter produced from the peanuts. The marked disagreements among the evaluations made on identical samples by the different laboratories emphasize the need for a universal quality standard within the peanut industry for flavor evaluation of farmers' stock peanuts.

(MQ 3-26(c))

B. Quality maintenance in storage

1. Flaxseed Storage. Under P.L. 480 grant in Poland, research on the influence of storage changes on quality of seed and properties of linseed oil has been underway for three years. The initial phases of the studies have been completed and included a study of the composition of seed of different varieties grown in several areas and at several stages of maturity. Different methods of analysis were evaluated in order to demonstrate that test data can provide the best measure of changes in quality during the storage of the seed.

(E21-AMS-6)

2. Soybean Oil Storage. A 4-year study of the effect of long-time storage of soybean oils under simulated commercial conditions was completed. Crude, degummed and refined soybean oils were stored at Beltsville, Maryland. Time-temperature relationships will be derived from data obtained in this study whereby predictions can be made of quality of oils after any length of storage at any known location.

(MQ 2-44)

3. Natural Antioxidants in Vegetable Oil Storage. Work was initiated on the effect of added natural antioxidants and synergists on refined vegetable oils in storage. Refined oils with added natural antioxidants will remain in storage at several constant temperatures over a 3-year period in order to determine the efficacy of these substances and relate the rate of change in quality to data previously obtained on stored refined oils.

(MQ 3-25)

4. Vegetable Oil Storage. A study has been initiated under a P.L. 480 grant in Florence, Italy, to investigate the effect of different types of containers on long-time bulk storage on the quality of vegetable oils, and to examine the natural antioxidants and their effect upon the quality of the oil. Some commercially available antioxidants will also be evaluated. This project was initiated during the past year, using cottonseed, soybean, peanut, sesame, and olive oils.

(E15-AMS-12(k))

C. Prevention of insect infestation

1. Insecticide Evaluation. Preliminary tests were conducted at Tifton to develop a technique for the application of candidate insecticides to commodities for preliminary laboratory evaluation. An 8-quart twin shell liquid-solid V-type blender reported to be highly suitable for this type of application was procured and tested. Malathion was applied to farmers' stock peanuts at five different rates and with six different batch sizes in the blender. Results of chemical analyses revealed that malathion deposited on the peanuts averaged less than 30 percent of that added in the blender. It was decided all stations would use a simple tumbling technique evaluated and found effective at the Savannah station for applying candidate insecticides to commodities for the evaluations to be conducted under this project.

(MQ 1-15)

A few compounds found promising at Savannah under Line Project MQ 1-23, were applied to farmers' stock peanuts and tested at Tifton against confused flour beetles in laboratory evaluations. One of the three compounds tried rated higher on initial toxicity than the standard malathion treatment. The test is continuing to determine the duration of residual effectiveness.

(MQ 1-15)

Exploratory fumigation tests were conducted at Savannah with methyl bromide. Adult red flour beetles were exposed 24 hours at 80° F. \pm 4° in 20-liter bottles 3/4 full of farmers' stock or shelled runner peanuts. The lowest dosages producing 100-percent mortality were 8 mg./liter in farmers' stock and 14 mg./liter in shelled peanuts. Inorganic bromide residues resulting from methyl bromide dosages of 2 to 10 mg./liter ranged from 5.1 to 12.0 p.p.m. in shelled peanuts and 7.3 to 20.0 p.p.m. in farmers' stock peanuts. (Exploratory, prior to establishing line project.)

Much of the cross commodity insecticide evaluation work at Savannah has application to peanuts but the entire report is included in Area 13.

2. Insecticidal Control. The malathion bulk treatment for farmers' stock peanuts, applied at the time of storage, supplemented by periodic surface treatments during storage, was developed by research as reported previously. It was found to be the most effective and most economical treatment yet available for protecting stored peanuts. It is used extensively by the peanut industry, and is included in the storage contract for government-owned peanuts. A survey of storage warehouses was made following reports that the malathion treatment was failing to control insects in the 1962 crop. It was found that in some cases the malathion spray had not been applied properly at the time of load-in. In other cases the surface sprays had not been started soon enough or had been improperly applied. More warehouses had moth infestations on the surface of the peanuts this year than last year at the same time. The Ephestia moths were more prevalent than the Indian-meal moth, whereas the two have been about equally abundant in peanut warehouses in the past. There were fewer beetles found in the stored peanuts than in former years.

(MQ 1-14)

Moths collected from peanut storage warehouses where malathion treatments had been used for 1 to 3 years were taken to Savannah to find whether malathion resistance may have developed. Cultures were established and contact toxicity tests were conducted with malathion against larvae. Strains of both Ephestia and Indian-meal moth larvae from the peanut warehouses were less susceptible to malathion than were those from sources without previous exposure to malathion. Observations are continuing to determine the degree of tolerance to malathion and whether it is sufficient to prevent adequate practical control.

(MQ 1-14)

Samples of peanuts were collected from some warehouses and were sent to Savannah for malathion analyses. The malathion deposits were very erratic from one warehouse to another, ranging from a low of 2.1 p.p.m. on probe samples to a high of 454.7 p.p.m. on surface samples taken soon after spray application. There was not adequate opportunity to check up in detail but it appeared that low deposit levels could usually be attributed to improper application. An extra malathion surface spray, to be applied in

December 1962, was authorized for all warehouses where it was needed for moth control. The regularly scheduled surface sprays kept the moths under control for the remainder of the storage season. Peanuts from only a few warehouses had any appreciable amount of insect damage at the time of load-out.

(MQ 1-14)

3. Insecticide Residue Analysis. Some residue information is included in the discussion of preceding items. The overall residue analysis program conducted at Savannah, Georgia, is reported in Area 13.

4. Nonchemical Control. Treatments recently developed by research have made it possible for farmers' stock peanuts to come out of storage almost completely free of insect damage and contamination. Since shelling plants are the next step in the movement of peanuts through the marketing channels, a question was raised as to their possible implication in cases where shelled peanuts are damaged or infested when they reach the customer. An exploratory investigation of shelling plants has revealed many insects that attack shelled peanuts do develop in the trash and broken kernels that may be permitted to accumulate in peanut handling and shelling machinery and around the plant itself. A total of 12 different kinds of stored-product insects was found in small samples of trash collected in different parts of a single shelling plant during one inspection. The most abundant insects were almond moth larvae, followed in order of abundance by corn sap beetles, flat grain beetles, and red flour beetles, with smaller numbers of the other eight species. These insects could provide a ready source for infesting peanuts as they pass through the shelling machinery or as they are held in the plant prior to shipment. (Exploratory, preliminary to establishing a line project.)

Research to develop effective methods for preventing insect infestation in stored peanuts without the use of pesticidal chemicals has been initiated. Tests to establish the time-mortality regression lines for red flour beetle adults and Indian-meal moth larvae exposed to pure nitrogen or carbon dioxide were completed. The red flour beetle adults were more susceptible to both gases, and nitrogen was more effective than carbon dioxide against both species. Preliminary results from studies currently in progress indicate (1) the viability of peanuts is not affected by storage for 3 months in high concentrations of nitrogen or carbon dioxide, (2) the oxygen concentration in the

atmosphere of hermetically sealed peanuts decreases below the level required to support the life of insects that infest stored peanuts, and (3) carbon dioxide is more efficient than nitrogen in purging oxygen from columns of peanuts. (Exploratory, preliminary to establishing a line project.)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Baker, Doris. 1963. A colorimetric method for determining free fatty acids in vegetable oils. Jour. Agric. & Food Chem., September.

Dickens, J. W., Beasley, E. O., and Turner, W. K. 1962. Measuring the milling quality of peanuts with a sample sheller. Proc. Second National Peanut Research Conference held N. C. State College, August 13-15, 1962.

Dickens, J. W., and Beasley, E. O. 1963. Effects of curing treatment on some physical properties of peanuts. N. C. Ag. Ep. Sta., Agricultural Engineering Information Circular No. 16, April 1963.

Kramer, H. A., Ernest, Jane V., Demaree, K. D., and Sidwell, A. P. 1963. Spectrophotometric investigations on peanuts with particular reference to estimation of maturity. Food Tech. 17(8) 1044.

AREA 7

COTTON AND COTTONSEED - MARKET QUALITY

Problem.

Cotton: Technological advancement in production, harvesting, and ginning of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting, and ginning practices in preparation for markets. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed: Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading, and standardization programs.

USDA PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, physicists, chemists, and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C., College Station, Texas, Clemson, South Carolina, in cooperation with Clemson College and by research contract with Clemson

College, Texas Technological College, Auburn University, North Carolina State College, and Stanford Research Institute.

The program includes the following foreign projects under P.L. 480: A grant to Centre de Recherches des Industries, Rouen, France, provides for an investigation of fiber maturity and breakage during mechanical processing of cotton, and the relation of these factors to processing performance and product quality. Its duration is 4 years, 1961-1965, and involves P.L. 480 funds of \$64,500 equivalent in French francs.

Another grant to the same institution provides for development of an instrument for homogenizing and orienting fibers in samples for cotton testing. Its duration is 4 years, 1961-1965, and involves P.L. 480 funds with a \$47,000 equivalent in French francs.

A grant with Fiber Research Institute, T.N.O., Delft, Holland, provides for a study of the influence of length properties on the mill processing performance of cotton. Its duration is 3 years, 1962-1965, and involves P.L. 480 funds with a \$58,000 equivalent in Dutch guilders.

The Federal scientific effort devoted to research in this area totals 20.2 professional man-years subdivided as follows: Cotton 17.7, with 4.7 under research contract; and cottonseed 2.5.

Work terminated during the period included: Development and evaluation of an electrical resistance method for rapid determination of length and length distribution of cotton fibers (MQ 3-4); investigation of the elastic energy of a mass of cotton fibers as a means for determining the spinning potential of lint cotton (MQ 3-6); development and evaluation of equipment and method for the rapid measurement of the quality of cottonseed oil and integration of such method with measurement of oil content of cottonseed (MQ 3-7).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurements and evaluation of quality of cotton

1. Development of Small-Scale Spinning Tests. Further research on this project is being done under contract with Auburn University. Investigations have been initiated on the effects of such variables as hank roving sizes, twists, spindle speeds, and traveler weights

on end breakage and spinnable limits yarn number. The results obtained from these investigations will be analyzed and a standard procedure developed for a small-scale spinning test.

(MQ 3-1(c))

2. Relation of Spinning Performance of Cotton to Color Grade. This research is being done under contract by Texas Technological College. Cottons from two crop years (1961-62 and 1962-63) were selected by the Cotton Division, AMS, and procured by the contractor. The processing of this study is now underway.

(MQ 3-13(c))

3. Evaluation of Interrelationships Between Cotton Fiber Measures. The first manuscript in an expected series of several was completed. Its title is "Interrelationships in Cotton Quality Evaluation: I. Five Factors, Including Fiber Strength 1/8" Gauge Versus 0 Gauge, as Related to Strength of 22s Yarn for Cottons of Three Staple-Length Levels." This report is the basic one of the series contemplated. Results are presented and discussed therein for six sets of analytical conditions.

It was concluded from these studies that fiber strength at the 1/8" gauge was a relatively "pure" measure of fiber strength for short staple cottons but with cottons of increasing staple-length, fiber strength measurements at the 1/8" gauge reflected a complex of increasing proportions, in the positive direction toward yarn strength. Within the framework of the foregoing definition, it was concluded that fiber strength at the 0 gauge was a relatively "pure" measure of fiber strength with the cottons of medium staple length but in short staple cottons the interrelationships were in the negative direction toward yarn strength and in the positive direction toward yarn strength with long staple cottons.

(MQ 3-17)

4. Effect of Various Production, Harvesting, and Ginning Practices on Spinning Performance and Cotton Quality. A study to determine the effects of certain harvesting and ginning practices on cotton fiber and processing performance has continued. These studies, in cooperation with other agencies, are being conducted by the AMS Cotton Quality Research Station, Clemson, South Carolina. Progress statements on the individual projects follow:

(a) Mechanical Picker Spindles. The processing of this study was completed for the second crop-year. The results indicate

(1) that the end breakage at spinning was less for hand-harvested cottons than for mechanically-harvested cottons and (2) that end breakage at spinning was also related to the type of picker spindle used in the mechanical harvesting of cotton. This study will be continued for a third crop-year.

(b) Mill Performance Vs. Pilot Plant Performance. This study is a cooperative ginning-spinning project among three mills and the Pilot Plant. It was designed to obtain a measure of the relationship of the level of ends down in Pilot Plant operation compared with mill operation. The processing of this study was completed by the Pilot Plant and is underway by the mills. The data will be analyzed as soon as the mill operations are completed.

(c) Roller Gin Vs. Saw Gin Study. This study was designed to compare the ginning performance, fiber qualities, and spinning performance of two varieties of long staple cottons ginned using conventional and experimental roller gins and a saw gin. The Pima S-2 cotton spun better when ginned with the experimental roller gin than with the conventional roller or saw gin but the reverse was true with Acala 1517D. Further investigations are being made.

(d) Moisture Restoration. This is a study of the effects of moisture restoration on the fiber and spinning quality of cottons. Preliminary results from a Mid-South cotton indicate that seed-cotton which had moisture restored between the seed-cotton cleaning and gin stand gave better spinning performance, longer fiber length, less short fiber, and higher break factor than cotton ginned at any moisture level without moisture restored. This also held true when the seed-cotton was artificially dried to a very low moisture level during seed-cotton cleaning. This study is being continued for another crop year.

(e) S.R.I. Drier Vs. Conventional Drier. This study was designed to compare the effects of an experimental and a conventional seed-cotton drier on fiber and spinning quality. The experimental drier uses conditioned air at approximately 110° F. at such relative humidity as to bring the cotton to equilibrium at the desired lint moisture level whereas the conventional drier uses higher temperatures to obtain the desired lint moisture level. Seed-cotton harvested at four levels of seed-cotton moisture content was dried to a lint

moisture level of 6 percent at time of ginning by each of the two drying systems. Another series of tests involved seed-cotton harvested at a constant level of seed-cotton moisture and then dried to three levels of lint moisture at time of ginning by each of the two drying systems. Fiber test results indicate no significant effects resulted from either of the drying systems used. However, limited spinning tests performed on cottons ginned under the extreme moisture levels on the two driers indicate some differences in spinning performance. Definite conclusions cannot be made until this study has been completed.

(f) Defoliation Study. This investigation concerns the effects of defoliation, desiccation, irrigation management, and field exposure in conjunction with various gin cleaning levels on fiber properties and spinning performance. This work is now underway.

(MQ 3-33)

5. Spinning Methodology Studies. Processing results for some of the ginning-spinning studies showed that the relationship of ginning conditions to end breakage at spinning, changes or even reverses when different yarn sizes, twist multipliers, and spindle speeds are used. The first methodology study was designed to determine the effects of changing spindle speed, twist multiplier, yarn size, and draft on product quality and spinning performance of two varieties of cotton. The results indicated that changes in spinning end breakage as a result of changing spinning drafts were different for the two varieties of cotton. The results of this study also serve as a guide in selecting the spinning organizations to be used in Pilot Plant operations. These methodology studies will be continued.

(MQ 3-33)

6. Electrical Resistance Method for Determining Cotton Fiber Length and Length Distribution. A manuscript entitled "Determining Cotton Fiber Length Distribution by Electrical Resistance Measurements" was cleared for publication and the project was terminated November 1962.

(MQ 3-4)

7. Elastic Energy of a Mass of Cotton. The investigation of the relationship of compressional properties of raw cotton to fiber processing performance has been completed. A manuscript entitled

"An Investigation of Compressional Properties of Bulk Cotton as a Means of Determining Processing Performance and Product Quality" was prepared for publication. This project was terminated January 1963.

(MQ 3-6)

8. Investigation of Chemical Residues on Surface of Cotton Fibers. A number of chemical compounds used in insecticides and defoliants have been obtained from several chemical companies. These compounds are being used to set up standards for identification purposes using paper and gas chromatography. Test methods and procedures for the detection of chemical residues are being developed. Preliminary tests on several studies have indicated the presence of chemical residues tentatively identified as DDT or toxaphene, by paper chromatography.

(MQ 3-42)

9. Measurement of Frictional Properties of Cotton Fibers. A commercially available "cohesion tester" has been acquired, altered, and incorporated into an electronic system which gives automatic averaging of "dynamic drafting force" and "dynamic drafting force variability" in the drafting of cotton slivers and rovings. Roller spacings are being varied to accentuate certain component variables in "dynamic drafting force." Preliminary tests indicate good repeatability for tests on drawing sliver.

(MQ 3-43)

10. Instrument Evaluation. Three cotton fiber testing instruments were received for evaluation. Two of these instruments, one experimental and one commercial, were designed to measure fiber length and length distribution and the other instrument (Trashmeter) was designed to measure surface trash on cotton samples. A progress report entitled "Evaluation of a New Air Device for the Measurement of Cotton Fiber Length and Length Uniformity" was given at the Cotton Marketing Conference-Research Clinic in April 1963 and at the Open House of the American Textile Manufacturers Institute in May 1963. In this evaluation, it was found that an air-flow technique could be used to measure fiber length and length distribution. The air-flow instrument measured the specimen accurately but problems still remain in the sampling device. Even though the results showed that the air-flow instrument was less sensitive and had lower repeatability than the Suter-Webb array technique, each method was about equal in predicting product quality and spinning performance on cottons which were processed in the Pilot Spinning Laboratory.

The Digital Fibrograph and a Fibrosampler are currently being evaluated. Preliminary results indicate that the Fibrograph measurements are not as sensitive as the array measurement to sample differences but measurements made on a limited number of samples indicate that both test methods are about equal in predicting product quality and spinning performance.

The evaluation of the Trashmeter is not yet underway.

(MQ 3-47)

11. Relationship of Fiber Maturity to Fiber Breakage During Mechanical Processing. A research project has been initiated in France under a P.L. 480 grant for an investigation of the relationship between fiber maturity and fiber breakage during the mechanical processing of cotton and the relation of these factors to processing performance and product quality. The work to date has been toward the development of the necessary tools and equipment for identifying fiber maturity and broken fibers.

The research to date indicates that fiber breakage was rather high in the cotton as it was received at the laboratory, and the least mature cotton had more breakage than the more mature cotton. Breakage during ginning is indicated. Little breakage occurred subsequently during the spinning process.

(E9-AMS-4(a))

12. Instrument for Homogenizing Test Sample. Under a P.L. 480 grant, a research project in France has been initiated to develop an instrument for homogenizing and orienting cotton fibers in a sample for fiber testing. Using a USDA fiber blender and a 2-roll drafting system with a collecting cylinder, an excellent sample for fiber testing was obtained when several layers of the drafted web were superimposed on the cylinder. This two-process operation is very slow. In order to get a faster method, two techniques were tried without success. They involved an electrostatic field for fiber transfer and combination of an electrostatic field with a perforated drum incorporating air flow to assist in the transfer of fiber from feed mechanism to the drum.

(E9-AMS-5(a))

13. Influence of Fiber Length Distribution on Mill Processing. A research project in the Netherlands has been initiated under a P.L. 480 grant to study the influence of fiber length distribution on mill processing of cotton. Two cottons (Deltapine and Acala) have

been selected for this project. Methods and procedures have been developed for modifying their length distribution by the addition of comber noils, and also by adding cut fibers obtained from the sliver of the cotton to give the same final length distributions. The processing of these cottons are now underway.

Preliminary results indicate that the addition of short fibers made by the cutting process caused a much higher increase in end breakage during spinning than short fibers obtained in a more natural fashion by the addition of comber noils.

(E19-AMS-8(a))

B. Objective measurement of quality of cottonseed

1. Determination of Moisture and Oil Content. Technical bulletins were prepared covering 4 years of field testing of the rapid methods developed for testing oil and moisture in cottonseed and moisture in oilseed meals. These methods employ USDA developed moisture and oil meters. An analysis of data covering both the dielectric method and standard laboratory method for oil content of cottonseed indicate that the degree of precision was about equal for both methods. However, the error due to the method appeared to be less for the meter method.

Results of testing the USDA moisture meter show that the test procedure and equipment meet qualifications for a rapid inexpensive method which can be used in grading small lots of cottonseed. The precision of results obtained with the moisture meter on cottonseed and soybean meals was less variable when compared with the standard laboratory method than those obtained with cottonseed. However, the method is acceptable for both soybean and cottonseed meals. A total of 950 oil-seed meals were tested for moisture content by both methods over a period of 3 years.

(MQ 3-5)

2. Rapid Determination of Free Fatty Acids. One of the qualities by which crude cottonseed oil is graded is the amount of free fatty acids it contains. The development of a rapid conductivity method for the determination of this acid content using our rapid oil meter allows the determination of both the oil content and the acid quality of the oil from the seed by a single extraction.

Neutralization of free fatty acids in oil with ammoniated butanol results in the formation of a salt, and the amount of salt dissolved in the organic solution is measured by electrical

conductance. However, the formation of additional ammonium salts, from material not actually free fatty acids, interferes with the "free fatty acid" determination of the oil by conductivity. The compound mainly responsible for this interference is the unstable ammonium salt of gossypol and to a lesser extent the ammonium salts of phosphatides. Good results were obtained by this method on crude oil from a new variety of glandless cottonseed. This new variety has been developed to eliminate the undesirable color pigment glands of gossypol in cottonseed. Our conductivity method can be used with the rapid oil meter to good advantage when this glandless variety becomes established.

The use of the conductivity method for the determination of free fatty acids in refined vegetable oil is possible because gossypol and phosphatides are eliminated in the refining process. Good results were obtained by this method when compared to the results obtained by the standard laboratory method. The advantages of this method over the standard method are: (a) Smaller amounts of free fatty acid can be detected; (b) color of the refined oil does not interfere with the determination; (c) only 5 grams of oil are required as compared to 50 grams by the titration method; and (d) the method lends itself to instrumentation thus eliminating greatly the variable human factor.

(MQ 3-7)

3. Method for the Rapid Measurement of the Refining Loss of Cottonseed Oil in Small Lots of Seed. Refining of crude cottonseed oil is necessary to eliminate compounds which influence the taste, color, and stability of the oil. The major compounds eliminated by refining are free fatty acids, gossypol, and phosphatides. Their elimination is possible by their reaction with sodium hydroxide or sodium carbonate to form sodium salts which are insoluble in oil. These same compounds have been found to react similarly with ammonium hydroxide in n-butyl alcohol to form a soluble ammonium salt and a measure of this ammonium salt concentration has been found to be related to their sodium salt potential. A conductivity method has been developed to determine this salt concentration. Correlation of this method (comparing oil extracts from cottonseed with actual plant refining losses of oil extracted from the same seed) will be the basis of a study to be conducted at several oil refineries. Conductivity instruments which were recently built under contract will be used.

(MQ 3-45)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

- Baumann, Lewis, A. 1963. The new method for grading collaborators in the Smalley check sample series. Journal AOCs. 40 (8), pp. 13, 14, 22. (MQ 3-5)
- Graham, J., and Carpenter, F. 1963. Evaluation of a new air device for the measurement of cotton fiber length and length uniformity. Paper presented at Cotton Marketing Conference-Research Clinic, Atlanta, Georgia, April 1963, at the American Textile Manufacturers Institute Open House, May 1963, and published in the Cotton Gin and Oil Mill Press, pp. 36-38, April 27, 1963. (MQ 3-47)
- Hartstack, A. W. 1963. Determining fiber length distribution of cotton by electrical resistance measurements. MRR 581, AMS, USDA, January 1963. (MQ 3-4)
- Looney, Z. M., LaPlue, L. D., Wilmot, C. A., Chapman, W. E., and Newton, F. E. 1963. Multiple lint cleaning at cotton gins: Effects on bale value, fiber properties and spinning performance. MRR 601, AMS, USDA, May 1963. (MQ 3-33)
- Newton, F. E., and Shanklin, E. H. 1963. Spinning performance evaluation of cotton: Effects of spindle speed, twist, yarn number, and draft on spinning end breakage. Paper presented at Cotton Marketing Conference-Research Clinic, Atlanta, Georgia, April 1963, and published in the Cotton Gin and Oil Mill Press, pp. 20-21, April 27, 1963. (MQ 3-33)
- Shanklin, E. H., and Newton, F. E. 1963. Evaluation of a small-scale and a large-scale spinning performance test, USDA, AMS-491, January 1963. (MQ 3-1)
- Shanklin, E. H., Calkins, E. W. S., and McCaskill, O. L. 1963. Effects of cotton ginning practices on market quality of cotton - A Mississippi Delta variety 1958-59. MRR 576, AMS, USDA, January 1963. (MQ 3-33)

AREA 8

WOOL AND MOHAIR - MARKET QUALITY

Problem.

Wool varies widely in quality factors that affect its value and use. Impurities in grease wool are a major problem, and an objective method of estimating the clean yield of grease wool is badly needed. Also needed are procedures and instruments to measure accurately the fineness and length of fibers. Animal fibers in raw or manufactured form are subject to damage by fabric insects, which are estimated to cause annual losses of about \$350 million. Effective and safe control methods are needed to be used in homes, retail stores, warehouses, woolen mills, and manufacturing plants to control the fabric insects that infest the premises. Improved fabric treatments and methods of application are needed to prevent the extensive feeding damage by insects. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information leading toward the development of better preventive treatments, and as an aid to the Western Utilization Research and Development Division in its program on the improvement of wool by molecular modification. Urgency is attached to the need for the development of safe and effective mothproofing treatments as a result of the concern about pesticide residues in clothing expressed by the President's Science Advisory Committee in its 1963 report on the use of pesticides.

USDA PROGRAM

The Department has a continuing long-term program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool, mohair, feathers, animal hair, and articles made of these fibers against insect damage while in marketing channels, in military uses, and in the home. The research is conducted in cooperation with the Armed Forces Pest Control Board, the Piano Technicians Guild, and various industry groups. Some work on quality evaluation of wool is also done.

A P. L. 480 contract with the Shri Ram Institute for Industrial Research, Delhi, India, provides for studies in the "canary coloration" of raw wools. Its duration is 5 years, 1963-1968, and involves P. L. 480 funds with a \$98,454 equivalent in Rupees.

The Federal scientific effort devoted to entomological research in this area totals 2.6 professional man-years divided as follows: insecticide evaluation 1.9 and insecticide residue analysis 0.4 at Savannah; and program supervision 0.3 at Hyattsville, Md.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. This is a new research project to be carried out under P. L. 480 funds in India. "Canary yellow" coloration of raw wool is an economic problem in both the United States and India. The research will provide basic information on the chemical nature of this coloration of raw wools, particularly regarding the role played by suint (dried perspiration) and its components, wax, and the keratin macromolecule itself in the presence of heat, light, and moisture. (A7-AMS-12(a))

B. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory biological tests were completed with 46 compounds to determine their efficacy in protecting woolen cloth against fabric-insect damage. Sixteen of the 46 were quaternary ammonium compounds and represented exploration of groups of less toxic chemicals for mothproofing, even before the President's Science Advisory Committee expressed concern over pesticide mothproofing residues in clothing. All 16 compounds provided a very high degree of protection against insect damage to the test fabric. When applied to wool cloth at 1.0 percent by weight in an emulsion bath, they showed excellent retention on the fabric through repeated drycleanings. Many quaternary ammonium compounds are commonly used as emulsifiers, bactericides, algacides, or deodorants. (MQ 1-26)

Studies with cationic quaternary ammonium surfactants showed that deposits of the benzyl types in wool cloth were more resistant to drycleaning than were deposits of the difatty types. Although the benzyl types did not completely protect wool cloth from insect damage, treated cloths subjected to 10 drycleanings incurred no

more damage in tests than did treated cloth in the precleansing tests. It was found the temperature of the application bath for benzyl-type quaternaries is not a critical factor for retention through drycleaning. The compounds were equally effective at all application temperatures of 100° F. or above. This is in sharp contrast to some fabric treatments that must be applied in a bath at 212° F. for adequate retention. Dye-bath applications of the benzyl-type quaternaries in combination with various insecticides showed that the quaternary by itself is more effective than the combination in protecting against insect damage, even after as many as 20 drycleanings. (MQ 1-26)

Further tests were conducted on the application of insecticides to wool cloth, in combination with various textile treatments to determine whether greater resistance to cleansing could be produced. Among the treatments tried were an oil- and water-repellent, a copolymer latex dispersion, and a melamine-formaldehyde precondensate resin. None of the combinations was any better than the insecticide alone. (MQ 1-26)

Followup studies with allethrin applied under dye-bath conditions showed that treated wool cloth was adequately protected against insect damage after 3 launderings and drycleanings. Preliminary tests with anionic surfactants show that those which are intermediates of alkyl aryl sulphonic acid have mothproofing properties when applied to wool cloth in dye-bath treatments. (MQ 1-26)

Studies are in progress with wool cloth impregnated with DDT at the Quartermaster Research and Engineering Center under standard procedures for dyeing piece goods. These studies were initiated because results of small scale laboratory tests conducted at Savannah showed that DDT deposits in wool cloth were highly resistant to cleansing when the DDT was applied under dye-bath conditions of pH2 and a water temperature of 212° F. Preliminary results of the current studies indicate that an application designed to impregnate the fabric with 0.2 percent by weight of the cloth will give satisfactory protection against insect feeding, according to CSMA standards, after 3 launderings or 10 drycleanings. A deposit of 0.3 percent of DDT by weight of the cloth gives satisfactory protection against insect feeding after 5 launderings or 10 drycleanings. (MQ 1-26)

Field studies were conducted in cooperation with members of the Piano Technicians Guild to determine the relative value of two insecticide formulations developed by the Savannah laboratory for the protection of piano felts. The formulation containing lindane, DDT, and Strobane was the more promising.

(MQ 1-26)

Much of the cross-commodity insecticide evaluation conducted at Savannah has significance to this area of work and is reported in Area 13.

2. Insecticide Residue Analysis. Some chemical analyses are conducted specifically for the fabric-insect project. The overall program of analytical work is reported in Area 13.

AREA 9

POTATOES - MARKET QUALITY

Problem. The problems arising from the number of potato varieties grown, areas of production, seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. Current emphasis on processing has created special problems in prolonged storage at elevated temperatures and protection from low temperatures in transit. This has substantially increased the need for research on the control of moisture loss and the reduction of bacterial and fungal decay. Higher temperature storage also involves control of sprouting, with increased emphasis on chemical sprout inhibitors. There are also major problems in the area of quality measurement. Objective indices are needed to identify quality factors that are important for specific product usage. Contemplated increased use of federal grades for processing potatoes has resulted in need for more information to relate characteristics of the raw product to quality of the processed product. Also needed are non-destructive methods and instruments for detecting and rejecting potatoes with internal disorders during grading.

USDA PROGRAM

The Department has a continuing long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California station. The studies at Beltsville involve specialized storage problems and basic research. Studies on market diseases are conducted at Chicago and New York City.

The federal scientific effort devoted to research in this area totals 6.0 professional man years. Of this number 0.5 is devoted to objective measurement of quality, 0.5 to handling and packaging, 1.5 to storage, 0.5 to quality maintenance during transportation, 0.5 to postharvest physiology, 2 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the reporting period included studies on pre-cut seed (MQ 2-5), storage and chipping quality of new varieties (MQ 2-8), low temperature effects on seed potatoes (MQ 2-19), ventilation of storage in relation to quality of Maine potatoes (MQ 2-35), internal black spot (MQ 2-37), bin vs. box storage (part of MQ 2-39), and decay as related to previous storage temperature (part of MQ 2-64).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Determining Susceptibility to Bruising. Investigation of the relationship of susceptibility of potatoes to bruising and physical properties was continued at East Grand Forks, Minnesota. An impact instrument developed in cooperation with ARS was tested to determine the relative susceptibility to injury of different lots of potatoes. The results obtained this season were inconclusive and indicated a need for modification of the testing technique. A device has been built to simulate commercial handling and is currently being tested. (MQ 3-40).

B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. Although about 50 percent more bruising occurred in Red River Valley potatoes (Red Pontiac variety) sized into storage than those not sized, the bruising was largely confined to non-grade defects. This confirms work done previously with Norlands. (MQ 2-78)

C. Quality maintenance in storage

1. Influence of Storage Temperature on Processing Quality of Potatoes. Irish Cobbler, Kennebec, Red Pontiac, and Snowflake potatoes were stored at 40°, 45° and 50° F. at East Grand Forks, Minn. The potatoes stored at 45° and 50° were treated with CIPC to inhibit sprouting. At monthly intervals for 10 months, 300-lb. lots were removed from storage for pilot plant processing into flakes and slices. The potatoes stored at 40° and 45° were reconditioned for 3 weeks at 60° to 70°. Satisfactory flakes were produced from all lots of potatoes throughout the storage period. Data for slices are not yet available. There was no consistent relationship between storage temperature and shrinkage. CIPC volatilized into the storage space successfully controlled sprouting at 45° and 50° for the entire storage period. (MQ 2-69)

2. Standards for Processing Potatoes. Spectrophotometric measurements were made at Beltsville, of color standards for typical potato chip colors. The spectral curves were reduced to trichromatic

coefficients. From the coefficients, Munsell renotations were prepared for the Fruit and Vegetable Division for possible inclusion in their revised grade standards for potatoes for processing. Repaints, in the Munsell Book of Color having notations close to those calculated, compared well visually. The designations for the potato color standards could be specified in the grade standard. Color could be obtained for use by both potato chip and french fry manufacturers. (MQ 2-69)

3. Effect of Methods and Rates of Ventilation on Quality of Maine Potatoes. The air flow occurring at various locations within the bins was measured with new equipment. The most uniform air flow condition occurred at about 2 cfm per bbl. At higher rates the air movement became uneven within the pile.

The highest air flow rate (4 cfm/bbl.) gave best control of storage soft rot, whereas the intermediate rates (1, 1½, and 2 cfm/bbl.) showed considerable variation. Apparently at these intermediate rates the moisture is removed from the bottom of the pile and redeposited in the upper layers resulting in greater rot development. This condition has varied with the season and the crop condition. (MQ 2-35)

4. Deep Bin vs. Pallet Box Storage. Nearly 20% of the potatoes were damaged when harvested into a hopper body and placed in a bin with a bin loader as compared to less than 1% damage when harvested into pallet boxes. Federal-State inspection showed 2.4% grade defects due to mechanical bruising in potatoes stored in the bin lot as compared to 1.3% in the pallet boxes. Silver scurf covered one-quarter or more of the tuber surface of 12.3% of the potatoes from bin storage as compared to 5.9% of the tubers from pallet box storage. (See also 9-F-5). This work has been completed. (MQ 2-39)

5. Internal Sprouting. In the 1962-63 season potatoes dipped in 0.5% CIPC suspension at Beltsville developed neither external nor internal sprouts during 18 weeks at 62° F. Untreated Katahdins stored in the same chamber with the dipped potatoes, developed 0.4 lbs. external sprouts per hundredweight of tubers and 1% internal sprouting, while untreated Irish Cobblers developed 1.4 lbs. external sprouts per cwt. and 10% internal sprouting. In the same building but in a separate room from the dipped potatoes in chambers, untreated Katahdins developed no internal sprouting while untreated Irish Cobblers developed 6.4% internal sprouting. All sprouting in this building which contained CIPC treated potatoes was of the appressed rosette type. Potatoes in chambers in a separate building used entirely for potato seed storage developed a different type of external sprout growth with sprouts mostly over 2 feet long and none of the appressed rosette type. Only one Katahdin tuber (.2%), in the CIPC-free building, developed internal sprouting through a crack near an eye. External sprouts averaged 7.8 lbs. per cwt. of Katahdin tubers

and 14.6 lbs. per cwt. of Irish Cobbler tubers. (MQ 2-31)

6. Application Methods of CIPC. The 1962-63 study in Maine indicates that moderate air flow rates from 1 to $1\frac{1}{2}$ cfm per bbl. resulted in more uniform distribution of the inhibitor within the pile than higher or lower rates. Residue analysis indicates no apparent residue problem when the recommended rates are applied. The highest residues were at the high air flow ($2\frac{1}{4}$ cfm/bbl.)

Treated tubers held in storage for 160 days had almost complete sprout inhibition but some rosette-type sprouts were present on tubers at the bottom and along the edges of the pile. A few internal sprouts were in the initial stage of development but the percentage of affected tubers was very low. The tubers were firm and the quality good.

CIPC was applied to tubers stored in pallet boxes with good sprout inhibition and no internal sprouting.

Emulsifiable CIPC was applied to skinned tubers of several potato selections with little or no effect upon the formation of wound periderm in storage (MQ 2-31)

D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes. California-grown Kennebec potatoes for chip manufacture, harvested at different times during the season appear to have different transit temperature requirements. Potatoes harvested during May and early June produced chips with satisfactory color when held at relatively low temperatures (55 to 65° F.) for 5 and 9 days. Potatoes harvested during late June produced darker chips when held at 55 or 59° F. than when held at 65, 70 or 75° F. Potatoes that produced dark chips after 5 or 9 days could not be reconditioned by holding an additional 4 days at 75° F.; rather, they generally produced even darker chips after this treatment. Holding potatoes at 75° rather than 70° F. during simulated transit did not improve chip color.

Kennebec potatoes are frequently shipped to the midwest under Standard Ventilation during the early part of the season when ambient temperatures are relatively low enroute. Transit temperatures of two rail cars of Kennebec potatoes shipped under Standard Ventilation averaged 64° F. during late May and early June. This temperature appears to be satisfactory for early season potatoes under this year's growing conditions. White Rose potatoes were hydrocooled in a flood-type hydrocooler to determine the rate of cooling. The half-cooling time for 2-inch diameter potatoes completely exposed to the water or jumble stacked (5 layers high) was 11 minutes. (MQ 2-55)

2. Relation of Oxygen and Carbon Dioxide to Decay. In tests with high nitrogen, low oxygen atmospheres at Harlingen, Texas, Lasoda

potatoes had 10 percent bacterial soft rot following exposure for 10 days to less than 1 percent oxygen either with or without an absorbent for carbon dioxide. Negligible rot occurred when oxygen was $2\frac{1}{2}$ percent or higher. As expected, low oxygen increased sprouting. (MQ 2-71)

E. Postharvest physiology

1. Suberin Formation. Shikimic, ferulic, and chlorogenic acids, eugenol, hydrogen peroxide, catechol, P-cresol and phenylthiourea were tested for their effect on suberin development on slices of Irish potatoes during 2 days' holding at 70° F. in moist chambers. Only slices treated with phenylthiourea at 5×10^{-3} M consistently developed a better suberized layer than untreated slices. Its effect in increasing this barrier was more pronounced on slices of Katahdin than on Irish Cobbler, Pontiac, or Idaho Russet Burbank. (MQ 2-5)

F. Postharvest disease control

1. Pre-storage Washing. Maine potatoes were washed at harvest, 1 month after harvest, and during the winter just before marketing. Those washed in the fall were held in storage for winter marketing. Only 51 percent of the potatoes washed at harvest were marketable by winter. Fifty-eight percent of those washed 1 month after harvest were marketable while 63 percent washed during the winter were marketable. Lenticel infection was about twice as great in the fall-washed potatoes as in those washed in the winter. (MQ 2-39)

2. Decay as Related to Previous Storage Temperature. The effect of chilling on the phenolic metabolism and susceptibility of Katahdin and Kennebec potatoes to fusarium decay was investigated at the New York Market Pathology Laboratory. Tuber slices stored at 32° F. for 10 weeks were more susceptible to decay when held at 70° F. than slices of potatoes stored at 40° F. or 52° F. Kennebecs were more susceptible than the Katahdins when stored at 32° F. After 6 days non-inoculated cut tissue of tubers from 32° storage contained 54% more O-dihydric phenols than non-inoculated cut tissue from 40°. Inoculated cut tissue of tubers from both storage temperatures accumulated O-dihydric phenols at a slower rate than non-inoculated cut tissue. Diffusates from cut tissue of tubers stored at 32° F. promoted more germ tube growth of conidia of Fusarium solani, f. radicola after twenty-four hours than diffusates from cut tissue of tubers stored at 40° F. (MQ 2-64).

3. Internal Black Spot. Data from the 1962-63 storage studies in Maine showed a high incidence of pressure bruising but little internal black spot in all treatments. Various field-applied fungicides had no significant effect on the development of internal black spot in tubers which had been held 6 months under 500 psi pressure at 38° F. and

95% R.H.

A higher percentage of potatoes developed pressure bruising in deep bin storage than in pallet boxes. No internal black spot developed in pallet boxes, whereas 10 percent of the potatoes from the deep bin developed internal black spot. No internal black spot was found in the non-pressure bruised tubers. (MQ 2-37)

4. Phoma in Potatoes. Phoma sp. was isolated from Maine potatoes in the Chicago market in 1963. Most of it occurred beneath bruised areas. Optimum growth of the organism on potato dextrose agar occurred at 68° F. Spore germination and cultural growth was inhibited at temperatures in the range 82-86°. Minimum temperature for growth of agar-mycelium transplants was 36°. No growth occurred on single spore inoculated plates held at 40°. (MQ 2-64)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Anonymous. 1963. Measuring Potato Bruising. Agricultural Research 11(7): p. 7. (MQ 3-40)

Storage

Hruschka, H. W., Marth, P. C. and Heinze, P. H. 1962. Internal Sprouting in Three Potato Varieties. (Abstract) American Potato Journal, Vol. 39, p. 392. (MQ 2-31)

Hunter, J. H., Toko, H. V. and Bondurant, B. L. 1962. Effects of Various Combinations of Air Flow, Temperature and Relative Humidity on the Keeping Quality of Stored Potatoes. (Abstract) American Potato Journal, Vol. 39, p. 392. (MQ 2-35)

Transportation

Hruschka, H. W., Akeley, R. B., Ralph, E. H., Sawyer, R. L., and Schark, A. E. 1961. Seed Potato Productivity After Cooling, Supercooling, or Freezing. Marketing Research Report 507. (MQ 2-19)

AREA 10

POULTRY PRODUCTS - MARKET QUALITY

Problem.

New technological developments in the poultry industries have created many problems relating to the market quality of poultry and egg products. The introduction of highly mechanized equipment and new techniques in processing have had variable effects on the absorption and retention of moisture of ready-to-cook poultry, on the contamination of poultry and egg products by spoilage micro-organisms, on physical damage to poultry carcasses, and on sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more precise information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and at Athens, Georgia, in cooperation with the Georgia Experiment Station and through a research contract with the University of California, Davis, California, on the effect of various disease syndromes on the wholesomeness of market poultry.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurements and evaluation of quality, and handling and packaging.

Studies on the quality retention of dressed poultry as related to method of washing and cooling (MQ 2-10) were terminated during this period.

A. P. L. 480 grant with The Ministry of Agriculture, Spain, provides for a study of the relation of changes in chemical and biological properties of lysozyme to changes in quality of shell eggs held in cold storage. Its duration is for 3 years, 1960-1963, and involves P. L. 480 funds with a \$17,094 equivalent in Spanish pesetas.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry. (carried out under contract with the University of California, Davis, California.)

Five experimental trials, designed to evaluate the pathogenic action of various combinations of disease agents in chicken fryers, were completed. Each trial consisted of inoculating 25 birds in each of 5 different age groups (total 125 birds) with the infective agents and then sacrificing all birds at the market age of 10 weeks for post mortem examination. The infective agents were (1) Newcastle disease virus (B₁ strain) and Escherichia coli (serotype 1-1), (2) infectious bronchitis virus (IBV) and E. coli, (3) IBV and Hemophilus gallinarum, (4) IBV and Mycoplasma gallisepticum (PPLO), and (5) PPLO and Newcastle disease virus.

In four of the five trials, the combinations of agents and the times and methods of infection tested thus far have not been successful in producing disease syndromes typical of those encountered during routine official inspection, particularly those involving extensive air sac involvement. The expected disease syndrome was obtained in all trials but the lesions were for the most part resolved prior to slaughter except for the IBV and Hemophilus gallinarum. A series of pilot trials using over 35 different combinations of infective agents, times, and methods of inoculation yielded information which will serve as a basis for additional trials with fryers. This study has thus far demonstrated that accepted concepts regarding the etiology of air sacculitis in chicken fryers may need to be modified.

(MQ 3-22(c))

2. Assessing the Sanitary Quality of Commercial Egg Products.

Bacteriological examination of more than 40 samples of commercial whole egg, yolk, and egg white solids was completed. Analysis of the data revealed that there were significant correlations between

the log of the standard plate count and the log of the enterococcus count. Correlation coefficients were 0.84, 0.97, and 0.95 for whole egg solids, egg white solids, and yolk solids, respectively. In every instance, enterococci outnumbered the coliforms, with numerous samples containing less than 10 coliforms per gram but relatively large numbers of enterococci. These results indicate that an enterococcus count should be a better index of the sanitary quality of dried egg products than a coliform count. A study in a commercial egg processing plant showed that the enterococcus count would also be a satisfactory indicator of sanitary quality of liquid egg and frozen egg. Studies with a dye reduction test utilizing resazurin and various tetrazolium compounds as a method for more rapid estimation of sanitary quality of liquid egg products were also initiated.

(MQ 3-31)

3. Methods to Evaluate Shelf-life of Eviscerated Poultry. A relationship was found between the bacterial content of drip from cut-up tray-packed poultry and the concentration of bacteria on the surface of the breast contained in the same package. The study indicated that each of the following methods may be used to obtain an approximation of the growth of microorganisms on cut-up tray-packed poultry meat during storage: (1) from individual lots of tray-packs determine the number of bacteria per ml. of drip from a different package each day; (2) determine number of bacteria in one milliliter of drip from the same package on successive days; (3) remove all drip from the same package on successive days and determine the number of bacteria per ml.; (4) on the first day of storage, place all drip from a representative package into a test tube, maintain the tube at the same temperature as birds and sample the drip from it on successive days for bacterial count. When these methods were compared to the actual total aerobic count on the breast of different chickens (swab technique) on successive days, the correlation coefficients obtained were 0.9, 0.9, 0.8, and 0.9, respectively. The importance of these findings is that (a) an indication of shelf-life of packaged birds may be obtained with fewer samples than was previously necessary; (b) errors due to bird-to-bird variations can be reduced and; (c) sampling of drip can be carried out repeatedly with only minimal effect on the package and no effect on the poultry meat.

(Exploratory Work--Project Pending)

B. Quality maintenance in handling and packaging

1. Airborne Microorganisms in Broiler Processing Plants. Airborne microorganisms were determined in two poultry processing plants using Anderson samplers and a mobile power supply. Total aerobic bacterial counts were highest in the dressing room with diminishing numbers in the shackling, eviscerating, and holding rooms when sampling was carried out during plant operation. The average counts per cubic foot of air in these four rooms were 2,200; 560; 230; and 62, respectively. As would be expected, the number of molds, coliforms, enterococci, psychrophiles, and total aerobic bacteria increased in the shackling and dressing rooms once processing was begun. Average total aerobic bacterial counts taken at 5:00 a.m. (before plant operation began), 9:00 a.m. and 2:00 p.m. increased from 70 to 870 to 3,000 respectively in the shackling room and from 310 to 4,900 to 7,000 in the dressing room. Airborne molds probably originate from a source other than the poultry being processed.

(MQ 2-10)

2. Influence of Polyphosphates and Other Compounds During Chilling on Quality of Eviscerated Poultry. A study was completed on the experimental effects of sodium polyphosphates on weight of fryer chickens during chilling. Phosphate-treated chickens gained less during chilling than control chickens, but when weighed after 24 hours, both groups showed about the same gain, indicating less moisture loss in the phosphate-treated birds. If continuous chilling preceded a 6-hour soaking period (in either phosphate solutions, plain water, or NaCl solutions), the moisture absorbed by chicken carcasses usually exceeded the limits established by USDA. Birds which exhibited a low percentage gain in weight during chilling, lost less moisture and for a shorter period of time after chilling than birds which showed a high percentage gain. Sodium chloride (ordinary salt) in amounts permitted by USDA in chilling media had no significant effect on moisture pickup. Birds chilled at pH 10 showed a significantly higher percentage gain in weight than birds chilled at pH 3,5,7,8, or 9. Within the limits of this study, neither time of air agitation, nor temperature, of the chilling media significantly affected percentage gains. This project was terminated.

(MQ 2-10)

3. Relation of Broiler Part Size and Weight to Carcass Weight. In a cooperative study with the Transportation and Facilities Division, a study to determine the relations of weights and sizes of broiler

parts to carcass weights was conducted. In the study, a large number of broilers were cut up, and the weights, volumes, and dimensions of the parts measured. Weight, volume, and dimensions of broiler parts can be predicted with reasonable accuracy if the carcass weight is known. Sizing of the carcasses can be used as a basis for providing uniform parts for portion-control packages (each package containing parts of the same size), and for convenient selection of parts to make up packages of an exact weight. The percentage relationship of weights of parts to the carcass weight was found to be approximately the same for all weight groups. (MQ 2-41)

4. Eating Quality of Ice-Packed and Frozen Chicken. In a study dealing with organoleptic acceptance of ice-packed and of frozen chicken, a laboratory panel evaluated light and dark chicken meat from halves of the same chicken ($\frac{1}{2}$ ice-packed; $\frac{1}{2}$ frozen) over a 14-day storage period. There was a small but consistent preference for flavor of frozen light meat over ice-packed after the third day of storage. The same trend was evident in dark meat but the degree of preference was much less. Differences in juiciness and tenderness scores between treatments were very small.

In a second study, a home consumer taste panel was set up in which 74 families in the Athens, Georgia, area participated. Participants were chosen at random and were asked to evaluate two chicken halves as to various characteristics. One-half of each chicken had been frozen, then thawed, whereas the other had been ice-packed. Two halves of a chicken were delivered to each family each week for 3 weeks. Provisions of the study were set forth in an instruction sheet. Upon evaluation of the samples, each family returned a report card of their preferences, cooking method used, and reason for preference of one sample over the other. It was found that there were more participants (about 7 percent), who chose the fresh samples over the frozen. In the first and second week, about one-third of the participants could not differentiate between the halves. In the third week, a greater number of participants than previously could differentiate. The combination of "Taste and Tenderness" was the largest category for reason of choice. Cooking technique was found to have no significant effect on the reasons for choice. (MQ 2-41)

5. Capillary Fragility and Bruise Healing of Broilers. Studies on the effect of oral intake of ascorbic acid and hesperidin on capillary fragility and bruise healing of broilers were not clear

cut. Further work is needed. Hesperidin showed some promise in reducing bruise incidence in commercial handling. Ascorbic acid appeared to cause some reduction in strength of capillaries but significantly reduced healing time of bruised birds.

(MQ 2-41)

6. Quality Retention of Eviscerated Poultry as Related to Method of Slaughter. A prototype apparatus for slaughter of poultry was designed, constructed and is being tested to determine whether better control of bleeding during slaughter of chickens can be obtained. The apparatus consists of a plunger device for stunning the bird by skull penetration similar to that used on larger meat animals. It differs in that vacuum is applied through the hollow plunger after penetration to enhance blood removal.

(MQ 2-81)

7. Changes in Eggs During Cold Storage. The effect of storage for up to 10 months at 0° C., 85-90% R. H., and 2° C., 90-95% R. H., on egg quality was studied under a P.L. 480 grant in Spain. No important differences were found as a function of these temperature and relative humidity conditions. Under both, the proportion of thin albumen increased and Haugh units decreased, and thin albumen viscosity and lysozyme activity showed no consistent pattern of change.

Microbiological studies showed that Penicillium was the mold in greatest occurrence during storage, and that the isolation of Pseudomonas increased in frequency during storage. Lysozyme, both in-vitro and on-site, proved to have very slight, if any, effect against Pseudomonas.

Oiling was superior to plexiglas, which in turn was superior to no shell treatment, in maintaining quality.

(E25-AMS-5(a))

8. Rancidity in Cooked Poultry. The effectiveness of polyphosphates in delaying rancidity development in commercially processed and cooked fryer chickens was investigated. Analysis of the data is in progress.

(Exploratory work - no line project)

9. Shelf-life of Prepackaged Cut-up Poultry. Prepackaged cut-up fryer chickens which had been frozen for 3 months and then thawed were evaluated to determine if differences in shelf-life could be

discerned when five different types of overwraps were used. Overwrapping material studied included: Polyethylene (1 mil); Polyvinyl Chloride (1 mil); Irradiated Polyethylene (1 mil); Polypropylene (1 mil); and Polyvinyl Chloride ($\frac{1}{2}$ mil). There was no significant difference between the bacterial counts on the breast or in the drip that could be attributed to differences in type of overwrap. Average shelf-life of the five groups, placed in a 34° F. cooler in a frozen condition, was about 26 days. The percentage drip increased with the increased storage (significant at 1% level) but no difference in the amount of drip resulted from differences in overwraps.

(Exploratory Work--Project Pending)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Tarver, F. R., Jr., May, K. N., and Boyd, F. M. 1962. Sampling technique for the enumeration of microorganisms in the diverticulum of the anterior thoracic air sac of chickens. Applied Microbiology, 10: 137-140. (MQ 3-22(c))

Walters, R. E., and May, K. N. 1963. Thermal conductivity and density of chicken breast muscle and skin. Food Tech. 17: 808-811. (MQ 2-41)

Walters, R. E., May, K. N., and Rodgers, P. D. 1963. Relations of weights and sizes of broiler parts to carcass weights. Marketing Research Report No. 604. (MQ 2-41)

Quality Maintenance in Handling and Packaging

Kotula, A. W., Thomson, J. E., Novotny, J. F., and McNally, E. 1963. Bone darkening in fryer chickens as affected by calcium and phosphorus levels in their diet. Poultry Science 42(4) pp. 1009-1014. (Exploratory work--no line project)

Kotula, A. W. 1963. Poultry slaughter techniques - a review. The Maryland Poultryman, July, p. 2-5. (MQ 2-81)

May, K. N. 1962. Bacterial contamination during cutting and packaging chicken in processing plants and retail stores. Food Tech. 16(8): 89-91. (MQ 2-10)

- May, K. N., Helmer, R. L., and Saffle, R. L. 1963. Effect of phosphate treatment on carcass weight changes and organoleptic quality of cut-up chicken. Poultry Science 42: 24-32 (MQ 2-41)
- Tarver, F. R., and May, K. N. 1963. The effect of bleed time prior to scald and refrigerated storage upon bacterial counts in the diverticulum of the anterior thoracic air sac of chickens. Food Tech. 17: 198-200. (MQ 2-10)
- Thomson, J. E., Kotula, A. W., Novotny, J. F. 1963. Experimental effects of sodium polyphosphates on weight of fryer chickens during chilling. Marketing Research Report 605. 15 pp. (MQ 2-41)

AREA 11

TOBACCO - MARKET QUALITY

Problem.

Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program has resulted in a large buildup of stocks, some held for as long as 7 years, about twice the normal period for storage and aging. The long-term storage and the compact, dense structure of the tobacco as stored in hogsheads make insect control difficult. Repeated, heavy applications of fumigants or other control measures during extended storage has raised a question as to the extent and significance of residues that may be accumulated. Treatments applied during storage should be assessed further to be sure they are safe. Measures now used only hold insect populations in check and do little to reduce them or prevent them from becoming established. Attention should be given to the development of measures that will minimize or eliminate the use of chemicals, and at the same time effectively eliminate or prevent infestations. To accomplish this it will be necessary to develop much more basic information than is now available on the ecology, physiology, and behavior of the insects that attack stored tobacco.

USDA PROGRAM

The Department has a long-term program at Richmond, Virginia, involving entomologists engaged in basic and applied research on the insect problems of stored tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers co-operative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department.

A continuing program of basic and developmental research at Savannah, Georgia, involves entomologists and chemists whose work has cross-commodity application. Although much of the work has a direct relation to stored tobacco, only a part of the effort has been charged to Area 11. The program is reported in Area 13.

The Federal scientific effort devoted to entomological research totals 3.9 professional man-years divided as follows: basic biology and ecology 0.8, insecticide evaluation 1.4, insecticidal control 0.5, and nonchemical control 0.3 at Richmond; insecticide evaluation 0.2 and insecticide residue analysis 0.3 at Savannah; and program leadership 0.4 at Hyattsville, Maryland.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Basic Biology and Ecology. The tobacco industry rapidly put to work the results of research on flight habits of cigarette beetles and tobacco moths. The time of day for commercial spray applications has been changed to coincide with the peak period of insect activity, and the insecticide applications are more effective. Studies of the response of tobacco insects to light led to the development of the more efficient black-light trap now widely used in tobacco warehouses.

(MQ 1-7)

The recent discovery that a large percentage of cigarette beetles continue their reproductive cycle without ever emerging from tobacco hogsheads places a severe limitation on the effectiveness of space treatments as used for years in tobacco warehouses. On the basis of this information, attention is being given in the applied control projects to looking for ways to cope with this condition. Studies are also in progress to learn whether a new biological strain of the cigarette beetle may have developed that has a tendency not to emerge from the tobacco.

(MQ 1-7)

Studies have been initiated to learn more about the effect of moisture content of the tobacco and relative humidity of the atmosphere on the development of the cigarette beetle and the tobacco moth. A technique has been developed to control the moisture content in small samples of tobacco by means of specific concentrations of glycerol in glass dessicators.

(MQ 1-7)

2. Insecticide Evaluation. Several insecticides were applied as coatings on paper liners for 1-cubic-foot boxes of flue-cured tobacco. The boxes were placed in exposure rooms at Savannah, Georgia, where they were continuously subjected to an intense insect infestation to determine the protection that might be given to stored tobacco by the treated liners. A combination of methoxychlor, pyrethrum, and piperonyl butoxide gave complete protection for 6 months. Malathion was effective for 1 year but had some slight penetration after 2 years. Lindane and chlordane continued to give complete protection even after 2 years. Paper bands, either insecticidally treated or untreated, gave protection for 2 years in tobacco in hogsheads that had been "broken" for inspection, by preventing insect penetration into the crack in the otherwise dense mass of tobacco. (Observations on long-term studies in progress when line project BS 1-3(R) was discontinued.)

Part of the insecticide evaluation program at Savannah, Georgia, has been charged against tobacco. The entire report is included in Area 13.

3. Insecticidal Control. In a group of flue-cured tobacco storage warehouses it has been shown that a heavy early spring fumigation with HCN at 3 lbs./1000 cu. ft., followed by periodic applications of DDVP aerosol gives good protection against insect infestation. This type of "preventive program" was appreciably more effective than standard control measures in holding down damage to tobacco and in preventing the development of insect infestation. The use of the heavy initial fumigation dosage may also be at least a partial answer to the recently discovered problem of "non-emerging" cigarette beetles. This possible preventive program as suggested by results from an earlier line project (BS 1-70). The results justify further work.

(Exploratory)

4. Nonchemical Control. Preliminary studies of the effectiveness against insects of a new thermal-vacuum conditioning process for tobacco indicate that a peak temperature of about 140° F. with a steam cycle of 10 minutes is necessary to insure complete mortality of all stages of the cigarette beetle.

(Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation.

Stored-Product Insects Branch. 1963. Oil Base for Insecticide Sprays in Tobacco Warehouses. USDA, AMS-496, 2 pp. (MQ 1)

Stored-Product Insects Branch. 1962. Stored-Tobacco Insects--Biology and Control. USDA, Agricultural Handbook No. 233, 39 pp. (Revision of former Circular No. 869.) (MQ 1)

AREA 11 b

CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Problem. The rapid increase in production of field grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and North Carolina has raised many problems in marketing. Information on methods and materials for use in packaging, on the temperature requirements for storage and in transit, and on the prevention of decay are among the most urgent problems. Information is also needed on methods to prevent berry and leaf abscission and berry decay of greens, such as holly and mistletoe.

USDA PROGRAM

The Department has a very limited program in market quality research on cut flowers and ornamentals, amounting to approximately 1.0 professional man-year. This research is conducted at the Fresno, Beltsville, and Chicago laboratories. The work on quality maintenance during transportation is conducted in cooperation with the California Floral Traffic Conference.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in handling and packaging

1. Mistletoe. Studies to determine the effectiveness of certain chemicals for the prevention of berry and leaf abscission of packaged mistletoe were continued in Chicago. Mistletoe twigs, when dipped in 20 ppm solutions of 2,4,5-T or alpha naphthalene acetic acid, or in 50 and 100 ppm solutions of N₆ benzyladenine, had less than 1 percent berry and leaf abscission after holding 14 days at room temperature. None of these materials were phytotoxic.

Berry decay was effectively controlled for 14 days at room temperature by dipping the mistletoe twigs in 2000 ppm Dithane M-45, Botran, or Hyamine 3500 prior to packaging in 140 MSP or 300 MST cellophane bags. One-hundred ppm of 2-amino butane was slightly less effective and was also slightly phytotoxic. By adding 2,4,5-T or alpha naphthalene acetic acid to the fungicidal solution, leaf and berry abscission were also controlled. (MQ 2-15)

B. Quality maintenance in storage

1. Pine Seedlings. The Forest Service sometimes stores pine seedlings in commercial storages also used for table grapes. Consequently, the seedlings may be exposed to low concentrations of sulfur dioxide. The Service has experienced some poor stands of young trees that they believe resulted from exposure to SO_2 during storage.

In tests at Fresno, Calif., exposure to 2500 ppm SO_2 for 2 hours at weekly intervals severely damaged Ponderosa seedlings held 50 days at 32°F . On planting after storage, the leaves and many roots died within 3 weeks. At 1000 ppm growth was retarded, but the plants recovered. Slight retardation occurred at 100 ppm. Very little damage occurred at 10 ppm SO_2 .

Use of a fungicidal dip and storage in a polyethylene bag appeared promising as an improved handling method for pine seedlings. This technique saved the storageman the time and expense of wetting down the seedlings at intervals during storage and also was effective in retaining moisture around the roots. Captan and Botran dips caused no injury, but Harvan retarded growth. Decay was not a problem in any of the particular lots tested. (MQ 2-15)

C. Quality maintenance during transportation

1. Cut Flowers. Air shipping tests with flowers have shown that transit times, from packing in California to delivery at wholesale, range from 18 to 35 hours. Flower temperatures during transit were mostly in the 50° to 70° range, but extremes of 90° and 34° were observed.

Solutions to the problem of reducing losses in transit appear to lie in improved packaging to protect flowers from temperature extremes, refrigerated holding rooms at points where movement of flowers is delayed, and in modified atmospheres to supplement the limited refrigeration available. To test this latter solution, roses were held under various combinations of nitrogen, oxygen, and carbon dioxide for simulated transit or storage times.

An atmosphere of nitrogen with 0.5 or 1.0 percent oxygen significantly retarded bud opening and loss of red color in Better Times roses at 32° , 37° , 59° , and 70°F . The respiration rate of roses held in these atmospheres at 32° for 2 to 3 weeks averaged 13 ml $\text{CO}_2/\text{kg-hr}$, compared to 17 ml for those in a normal atmosphere at the same temperature. The respective rates at 59° were about 56 ml, compared to 98 ml $\text{CO}_2/\text{kg-hr}$. Atmospheres of pure nitrogen (zero O_2) damaged the roses.

Carbon dioxide at 5 or 10 percent levels in combination with 0.5 percent oxygen plus nitrogen at 59°F . for 40 hours retained color better than the same O_2 concentration without CO_2 . However, holding roses 3 weeks at 32° in 10 percent CO_2 and 0.5 percent oxygen caused injury.

Polyethylene bags were used to maintain modified atmospheres under simulated transit conditions. After 40 hours at 59° or 70° F., an atmosphere of about 2 percent O₂ and 4 percent CO₂ developed around roses packed in 1½ mil polyethylene bags, flushed with pure nitrogen before sealing. If a packet containing 50 grams of hydrated lime was placed in the bag, the carbon dioxide level was reduced to almost zero. The same procedure used with 2 mil polyethylene bags resulted in low-oxygen injury to the roses. However, flushing the bags before sealing, with a mixture of 2.0 percent oxygen and 98 percent nitrogen (rather than pure nitrogen) prevented injury--the oxygen level was about 0.7 percent after 40 hours. Without hydrated lime, the CO₂ increased to 6.0 percent, but did not adversely effect the quality under these conditions of time and temperature. (MQ 2-15)

D. Postharvest physiology

1. Ethylene Oxide Studies. Ethylene oxide appears to counteract the aging and ripening effects stimulated by ethylene. Ethylene oxide causes a reversible inhibition of ripening in tomatoes and plums, retards the opening of cut roses and prevents "sleepiness" in carnations normally induced by ethylene. The antagonistic effect of ethylene oxide on ethylene provides direct evidence for considering ethylene as a hormone.

Better Times roses, held for 20 hours at approximately 60° F. in an atmosphere containing 0.25% ethylene oxide, had 1 to 1½ days longer life than untreated roses. Carnations held in a tight chamber developed "sleepiness". Treatment with 1 ppm of ethylene produced severe "sleepiness". Addition of ethylene oxide to provide a concentration of 0.2% in the atmosphere surrounding the flowers prevented all symptoms of "sleepiness" in both chambers. Many tissues are very sensitive to injury by ethylene oxide and may require a very narrow concentration range and careful temperature control to obtain beneficial results. (MQ P-1)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance During Transportation.

Harvey, J. M., Uota, M., Segall, R. H., and Ceponis, M. J. 1963.
Transit Times and Temperatures of Transcontinental Cut-Flower
Shipments. Marketing Research Report No. 592. (MQ 2-15)

Postharvest Physiology.

Asen, Sam and Lieberman, M. January 10, 1963. Ethylene Oxide
Experimentation Aimed at Cut Flower Longevity. The Florists' Review,
Vol. CXXXI, No. 3398. (MQ P-1)

Asen, Sam and Lieberman, M. August 29, 1963. Ethylene Oxide Found
to Combat Deterioration of Carnations. The Florists' Review,
Vol. CXXXII, No. 3431. (MQ P-1)

AREA 12

VEGETABLES - MARKET QUALITY

Problem. Vegetables are subject to deterioration after harvest through normal and abnormal metabolic changes and by decay organisms. In addition they vary widely at harvest in the characters that determine market acceptance. Much additional information is needed on objective indices for harvest maturity, quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels. Research aimed at the reduction of wastage during marketing is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Consistently safe and effective transportation of the more perishable products can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments.

USDA PROGRAM

The Department has a continuing program of applied and basic research relating to measurement, protection, and improvement of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Maryland; Fresno, California; Miami, Florida; Orlando, Florida; New York, N. Y.; Chicago, Illinois; and Harlingen, Texas and at the North Carolina Agricultural Experiment Station in cooperation with this station. The work on lettuce precooling is conducted in cooperation with the Grower-Shipper Vegetable Association and the Western Growers Association who contribute financial support to the program.

A total of 15.0 federal professional man-years is devoted to this program. Of this, 2.0 are devoted to objective measurement of quality, 3.0 to quality maintenance in handling and packaging, 0.5 to quality

maintenance in storage, 2.0 to quality maintenance during transportation, 3.0 to postharvest physiology, 4.0 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the reporting period included: Decay and quality of California globe artichokes (MQ 2-2), mode of action of bacterial soft rot (MQ 2-3), relation between field temperature and russet spotting of lettuce (MQ 2-11), transportation and marketing western melons (MQ 2-14), transportation in mechanical refrigerator cars (MQ 2-18), loading patterns and icing practices on celery and peas (MQ 2-21), hydrocooling vine-ripened tomatoes (part of MQ 2-23), packaging and storage of beans (MQ 2-30), improved packaging of mature-green tomatoes (MQ 2-36), quality changes in apples and onions during marketing (MQ 2-38), tomato fruit tumor (MQ 2-54), handling and packaging cauliflower and prepeeled onions (part of MQ 2-61), and decay of prepackaged carrots (part of MQ 2-64).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. The new USDA Sweetpotato Skin Color Chart was improved. An individual color for each leaf of the fan can now be placed on a root and direct color comparison made through a hole in the color area. Color fans have been furnished to sweetpotato breeders in North Carolina, South Carolina, Georgia, Mississippi and Louisiana for experimentation. (MQ 3-50)

2. Tomatoes. Evaluation of the new USDA inspection procedure and the USDA Tomato Colorimeter continued in a number of locations. One of the principal tomato products manufacturers used the procedure exclusively in their purchase of tomatoes for manufacture in the Mid-West. Other large commercial concerns continued with the experimental evaluation of the new procedure and Tomato Colorimeter. (MQ 3-15)

B. Quality maintenance in handling and packaging

1. Dry Beans. A study was made to determine whether multiwall paper bags are as satisfactory as burlap bags for handling and storage of 100 pounds of dry edible beans at country points and terminals. No significant changes in fat acidity and moisture content of the beans were found in any lot during storage. Sampling of beans in paper bags was performed in the normal manner by probing. A special pressure sensitive tape was used to seal the paper bags which had been torn during probing. Every multiwall and burlap bag was inspected after the 10-month storage period and found to be in good condition. Multi-wall paper bags seemed to bridge areas better than burlap and hence stack more evenly. This work has been completed. (MQ 2-30)

2. Cauliflower. Three tests were conducted in New York with pre-packaged cauliflower cooled in a commercial vacuum-cooler. Prior to cooling, the heads were treated with: (1) 100 ppm sodium hypochlorite; (2) 1 percent sodium acid sulfite; or (3) 1 percent acetic acid. Vacuum-cooled, non-treated heads were used as controls. The average temperature of the heads was reduced from 67° to 42° F. during vacuum cycles of 40 to 50 minutes. After a short transit period and 3 days at 45° F., discoloration of bruised areas lowered the quality of the heads. None of the chemical treatments maintained the appearance of the heads during a 2-week holding period at 45° F. A small-scale exploratory study at Beltsville showed that brief hot-water treatments (2 minutes at 90° F., 1 and 2 minutes at 125°, 1 minute at 130°, and 30 seconds at 140°) before packaging were without value in preventing darkening or reducing spoilage of segmented cauliflower. This work has been completed. (MQ 2-61)

3. Lettuce. A wilted and discolored condition of the outer leaves was occasionally observed in retail stores in lettuce wrapped in heat-shrinkable film. In several tests in New York similar damage was produced by subjecting film-overwrapped heads to commercially applied heat-tunnel temperature of 285°-390° F. Heat-tunnel exposure times ranged from 1.7 to 5 seconds, the periods required for adequate shrinkage of the films used. Leaf damage occurred only in lettuce in the heat-shrunk films. Hard or overmature heads were most susceptible. Heat injury, besides affecting appearance, predisposed lettuce to decay. (MQ 2-64)

4. Prepeeled Onions. Prepeeled, whole and sliced onions were packaged at the New York laboratory in perforated and non-perforated polyethylene bags. The whole, peeled onions held up well for 1 to 2 days at 70° F. and for about 9 to 14 days at 41° F. The shelf life of sliced onions was about one-half as long. Excessive watersoaking of sliced onions was prevented by slicing them over 1/8-inch thick. Off-odors and off-flavors were noted in some non-ventilated bags after 2 days at 70° F. This work has been completed. (MQ 2-61)

5. Rhubarb. Tests were continued at Beltsville to determine shelf life of prepackaged cut rhubarb. Ways to prevent splitting and curling of outer layers, discoloration of cut surfaces and soft rot were tested. Rhubarb cut into 1-inch pieces and packaged in perforated (30 1/4-inch holes) 10-oz. polyethylene bags held up well for 2 to 5 weeks at 32° F., or for 3 to 7 days at 32° with an additional 1 day at 70°; for 7 days at 40°; for less than 3 days at 50°; and for 2 days at 70°. Rhubarb pieces packaged in polyethylene bags perforated with 30 1/4-inch holes held up slightly better than those in bags perforated with 2 1/4-inch holes. Drying cut ends in air before packaging helped prevent splitting of cut ends. Dipping cut pieces in 1 molar sucrose solution or 1 molar salt solution for various times up to 10 minutes greatly reduced splitting. However, after 2 days at 70° damage from

the sugar and salt solutions appeared.

Tests with whole stalks of rhubarb showed that unwrapped bunches with leaf blades on remained salable for less than 1 day at 70° and for less than 3 days at 32°. Unwrapped bunches without leaves lasted 3 to 7 days at 32° and 1 to 2 days at 70° with slight loss of turgor. Polyethylene-wrapped bunches of rhubarb with leaf blades on lasted 5 days at 32° plus 1 day at 70° or 7 days at 32°. Polyethylene-wrapped rhubarb without leaves lasted 7 days at 32° plus 1 to 3 days at 70°. (MQ 2-61)

6. Sweetpotatoes. In 7 truck shipments from North Carolina to Chicago, Ill. a loading pattern for corrugated fiberboard cartons was developed which reduced temperature variation within the load from the usual 15 or 20 degrees F. to 10 degrees or less. Air circulation was improved and hazard of chilling reduced during the winter months. After 8 days in the market roots shipped in corrugated boxes had about 5 percent decay. Decay of sweetpotatoes shipped in bushel baskets with excelsior lid cushions averaged about 8 percent and roots shipped in baskets without lid cushions averaged 14 percent decay. These corrugated boxes cost about 10 cents less per container than the commonly used veneer boxes or baskets.

Of 7 lid cushions and 2 basket liners tested to reduce injury and decay none gave better results than excelsior lid cushions and paper strip liners. Cushions reduced decay an average about 25 percent as compared with no cushions.

Packaging tests with freshly harvested roots confirmed data obtained last year. Treated roots packaged in perforated polyethylene bags, polymesh bags and in trays overwrapped with shrinkable films more than doubled the sales of sweetpotatoes, as compared to bulk displays, in Raleigh, N. C. stores. Weight losses from roots in bulk displays and in polymesh bags were 2 to 3 times greater than from roots packaged in perforated polyethylene bags. Weight loss from tray-packed roots was usually intermediate but could be controlled by type of wrap (sleeve vs. overwrap) and type and width of film. Several packing-houses now treating with sodium orthophenylphenate are packaging sweetpotatoes commercially. Weight loss and root temperatures were similar in sweetpotatoes stored in palletized field boxes, bulk pallet boxes, or bushel baskets. (MQ 2-73)

7. Vacuum Cooling. The relation of evacuation time to final temperature was determined in California for shrink-wrapped iceberg lettuce, lettuce in conventional cartons, film-wrapped trimmed cauliflower, and prepackaged ("cello") celery hearts vacuum cooled to various final absolute pressures. In general the vacuum cooling time was shortened by evacuation to 4.0 Mm. Hg. compared to the usual practice of breaking the vacuum at 4.6 Mm. Hg. The lower pressure

did not result in freezing injury when the produce was cooled in the usual shipping containers.

Commercial shrink-wrapped lettuce cooled as well as the conventional pack. However, cooling was dependent on an imperfect seal at the butt of the head and the openness of the pack, which allowed easy egress of moisture. Perforating the film wraps or the prepackaging bags improved the cooling. (MQ 2-80)

C. Quality maintenance in storage

1. Asparagus Plants. Second year yield data at Beltsville indicate the following results of prestorage root trimming of asparagus planting stock.

Plants with roots trimmed to 4 inches or 8 inches from crown or untrimmed had similar yields, when such plants had been packed in polyethylene, stored at 32° F., and planted immediately after storage. Plants trimmed to 8 inches, stored in burlap bags at 32°, and planted immediately upon removal from storage had higher yields than those trimmed to 4 inches or untrimmed, or any of the polyethylene-packed lots (trimmed or untrimmed).

Delaying the planting by 6 days with the roots at 60° F. (assumed transit conditions) reduced the yield of all plants stored in polyethylene, but increased the yield of plants packed in burlap with the exception of plants trimmed to 8 inches. (MQ 2-89 pending)

2. Onions. California-grown onions held 2 to 5 weeks in common storage before transfer to 32° F. storage had 4 to 7 times as many bulbs with physiological breakdown after 4 to 7 months' storage as lots stored at 32° immediately after curing. This confirms previous results. Bulbs held 5 weeks in common storage before storage at 32° had 3 to 5 times as much breakdown after 4 or 5 months' storage as those kept only 2 weeks in common storage. After storage for 6 or 7 months, there was little difference between a delay of 2 or 5 weeks.

Covering the bulbs with soil during growth reduced the amount of breakdown from an average of over 4% in uncovered bulbs to below 2%. Onions that were covered in the field and stored at 32° F. immediately after curing were completely free of breakdown even after 7 months.

The rate of cooling onions had no effect on the amount of breakdown that developed in storage. Rapid cooling did not cause a physiological "shock".

Exposure of bulbs to modified atmospheres with 5, 10, or 30 percent CO₂ at temperatures of 50°, 86°, or 104° F. for 24 or 48 hours prior to cold storage had no effect on the amount of breakdown that

developed during 5 months' storage. Brief intra- and intercellular accumulation of CO₂ during high temperatures is probably not a factor contributing to physiological breakdown. (MQ 2-56)

3. Sweetpotatoes. CIPC, applied as an aerosol, effectively controlled sprouting of sweetpotatoes. Taste panels could not detect differences between treated and non-treated roots which had been baked, or detect up to 10 ppm of CIPC added to reconstituted sweetpotato flakes. (MQ 2-73)

D. Quality maintenance during transportation

1. Artichokes. The half-cooling time for size 36 globe artichokes completely exposed to the water in a flood-type hydrocooler was 8 minutes and for crated artichokes was 12 minutes. Nomographs for predicting cooling times and temperatures were prepared from the data. This work has been completed. (MQ 2-2)

2. Asparagus. The response of asparagus to 8-day holding (to simulate a transit period) in atmospheres high in carbon dioxide (5, 10, 15, 20, or 30%) and low in oxygen (0, 1, 5, or 10%) was investigated further at Fresno, Calif. The low O₂ concentrations were tested because the use of liquid nitrogen as a refrigerant could result in atmospheres very low in oxygen in rail cars or trucks.

Asparagus held in 1% O₂ at 37° F. was almost free of low O₂ injury, but at 43° over 10% of the spears were injured. An atmosphere with five percent O₂ caused very little injury at either temperature. Complete lack of O₂ (100% N₂) injured the spears severely after 3 to 4 days. Low oxygen did not control soft rot.

Injury from CO₂ occurred at 43° F. in 10% concentrations regardless of O₂ concentration, while at 37° injury occurred only at 20 or 30% CO₂. Carbon dioxide injury was more severe at low O₂ concentrations (5 or 10% O₂) than at normal O₂ concentration (21%). Bacterial soft rot was reduced in proportion to CO₂ concentration at both 37° and 43° F. Control was almost complete in 15% CO₂ at either temperature, but this concentration was injurious at 43°.

These results indicate that asparagus should not be exposed to atmospheres containing less than 5% O₂ regardless of CO₂ concentration, or more than 10% CO₂ if O₂ is near 20%, or 5% CO₂ if O₂ is 10% or less.

Asparagus spears were hydrocooled in a flood type hydrocooler to determine the rate of cooling. The half-cooling time for spears completely exposed to the water was 1.1 minutes and for crated spears was 2.2 minutes. Nomographs for predicting cooling times and temperatures were prepared from the data. (MQ 2-13)

3. Celery and Peas. The half-cooling time for California-grown celery completely exposed to the water in a flood-type hydrocooler was 5.8 minutes, and for that packed in a Sturdee crate was 9.1 minutes. The half-cooling time for peas completely exposed to the water was 1.9 minutes and for those in a wooden tub was 2.8 minutes. This work has been completed. (MQ 2-21).

4. Lettuce. Transit temperatures of lettuce shipped in five conventional RS ice-bunker cars ranged from 36° F. to 39° F. with an average for all cars of 38°. (These cars were shipped under Standard Refrigeration with 2% initial salt and 4% salt added at each re-icing.) Average transit temperatures in three mechanically refrigerated cars ranged from 37° to 39°, essentially the same as those in the RS cars, but 3 to 5 degrees above the 34° thermostat settings. In one mechanical car, average trip temperatures of lettuce were the same in both ends of the car (37°). In two other mechanical cars, average trip temperatures varied by 2 to 3 degrees in opposite ends of the cars. Average trip temperatures in single-bunker thermostatically-controlled iced cars without bunker salt were 39° and 42°; in cars using 2 percent initial salt and 3 percent at each re-icing temperatures were 39° and 40°; and in a car using 3 percent initial salt and 5 percent at each re-icing temperatures averaged 37°. These single-bunker cars were equipped with metal air ducts extending beyond the doorway. These provided reasonably uniform temperatures in the 2 ends of the cars. (MQ 2-58)

5. Tomatoes. California-grown tomatoes had a half-cooling time of 10 minutes when completely exposed to the water in a flood-type hydrocooler and 11 minutes when jumble stacked (5 layers high). Nomographs for predicting cooling times and temperatures were prepared from the data. This work has been completed. (MQ 2-23)

A piggyback shipment of mature-green tomatoes from Florida, refrigerated with liquid nitrogen and controlled to the 5% oxygen level, was compared with a load shipped under mechanical refrigeration (60° F.). Commodity temperatures at arrival in the N₂ trailer were mostly above 80° with CO₂ in the atmosphere at 14%. Discoloration, pitting, and irregular ripening developed in the test fruit during ripening. Approximately 12% decay developed during ripening in comparison to 1% for fruit shipped under controlled 60° F. refrigeration. (MQ 2-53)

E. Postharvest physiology

1. Russet Spotting in Head Lettuce. The data obtained during the past season in California on the relation between air temperatures during growth and the postharvest development of russet spotting confirm those previously obtained. In each of 3 years, air temperatures above 86° F., 9 to 14 days before harvest, tended to increase post-harvest russetting in lettuce that was so exposed during this maximum

growth period. (MQ 2-11)

In several experiments at Beltsville the treatment of head lettuce with various antioxidants has given results ranging from nearly perfect control to no control of russet spotting. The variables responsible for the differential response have not been established.

Ethylene oxide, which has been found to counteract the effect of ethylene, retards the ripening of some fruits and the aging of cut flowers. At concentrations below 0.2% it did not prevent or delay russet spotting of lettuce. Concentrations above 0.2% with a treatment time of 18 hours induces an injury very similar to russet spotting. (MQ P-1)

2. Liquid Nitrogen as a Refrigerant. Experiments were continued at Harlingen, Texas to determine tolerances to atmospheres that might result with liquid nitrogen and carbon dioxide refrigeration. Atmospheres were maintained at 10, 20, and 30 percent levels of carbon dioxide; slightly less than 1, 2½, 5 and 10 percent levels of oxygen with nitrogen; and air. Produce items were held 5 to 20 days in controlled atmospheres followed by 4 to 7 days in air at optimum temperatures. Responses varied considerably between items and treatments. Broccoli was not affected by any of the atmospheres. Cabbage showed severe internal browning when held in less than 1 percent oxygen and the high carbon dioxide levels were conducive to development of black leaf speck. Carrots in plastic bags developed a temporary "off" flavor in 30 percent carbon dioxide and a sweeter flavor in less than 1 percent oxygen. Celery developed an "off" flavor in 20 and 30 percent carbon dioxide. Butts of vacuum cooled lettuce showed the least discoloration in 20 and 30 percent carbon dioxide but severe internal browning occurred during subsequent holding. Sweet peppers showed an increase in pitting when held 5 days in reduced oxygen levels at 40°F. but no pitting occurred at 45°. Bacterial soft rot increased progressively with higher levels of carbon dioxide. Weight loss was greater in produce held in air than in the modified atmospheres.

Tests were also conducted at Beltsville with mature-green tomatoes. Quality was seriously affected by holding in a 100% nitrogen atmosphere at 60° F. for 7 days. When removed to air at 70° following treatment, ripening was retarded to such an extent that most fruits decayed before they were completely ripe. After holding in 99% nitrogen, tomatoes ripened when removed to air but at a slightly slower rate than tomatoes that were held in air. When fully colored, tomatoes held in 99% nitrogen were as firm as those in air. (MQ 2-71)

F. Postharvest disease control

1. Carrots. Studies at Chicago on Geotrichium candidum, the organism causing "sour rot" of prepackaged carrots, have shown that it is favored by high temperatures and high humidity. The organism shows

marked tolerance to acid media and ability to acidify supporting media. A high percentage of germination occurred on water agar over the range of 50 to 95° F. during a 24 hour period. Spores held at 40° and 100° F. did not germinate. Carrot inoculations appear to be successful only when wounds are present with relative humidity near saturation and temperatures in the range of 70 - 90° F. The optimum temperature for growth on plates was 85°; the maximum temperature for growth was 100°. No growth occurred in 1 week at 40°. This work has been completed. (MQ 2-64)

2. Chinese Cabbage. Soft rot of Chinese cabbage and other leafy vegetables was dependent on a given concentration of causal bacteria being present in the host in experiments conducted in Florida. With Chinese cabbage tissue, the lower the temperature between 80° and 40° F., the higher the concentration of bacteria needed to produce infection. The rate of growth of the bacteria, their metabolism, and their pectinase enzyme production influence their ability to cause decay. In culture, raising the temperature from 40° to 80° F. increased growth, oxygen consumption, and pectinase production by 4, 12, and 16 times, respectively. Concentration of bacteria is reduced rather slowly at 32°. It is important that vegetables susceptible to soft rot be cooled rapidly after harvest to prevent build-up of bacteria to a point where they will cause infection to vegetables following precooling and during transit to the market. (MQ 2-47)

3. Escarole. The first evidence of breakdown of escarole is a physiological browning of leaf tips. This is followed by bacterial soft rot developing in this senescent tissue. Treating escarole with 10 ppm N⁶ benzyladenine delayed this physiological browning, thereby delaying the onset of soft rot. Treating escarole with N⁶ benzyladenine increased the shelf life by 2 days as compared with the untreated product. (MQ 2-47)

4. Irradiation. Tomatoes exposed to a dose of 500 krads in the mature-green, breaker, or pink stage did not ripen normally (at 70° F.) At 250 krads red coloration was delayed and softening accelerated. Irradiation also increased susceptibility to chilling injury. Fruit exposed to 125 krads had more decay than either the checks or those treated with higher doses when the fruits were chilled 8 days (37° F.) after irradiation and then ripened at 70°. When the fruits were chilled only 4 days or not at all, almost no decay developed regardless of irradiation treatment.

Green bell peppers exposed to 500 krads were undesirably soft after holding 7 days at 37° or 50° F. Lower doses had no effect on firmness. After holding an additional 4 days at 59°, all those irradiated were softer than the controls; and the calyx of the treated pods became soft and discolored. The effect on the calyx was just discernible on a few pods exposed to 125 krads, but was severe on all pods at 500 krads.

Exposure to doses up to 375 krads had no discernible effect on cantaloupes when examined after 7 or 10 days at 38° F. However, after an additional 3 days at 59°, lots exposed to 375 krads had only 1/8 to 1/3 as many fruits affected by stem scar mold as the controls. The effect of 45 and 125 krads was inconsistent. Placing a piece of adhesive tape over the stem scar before irradiation reduced the incidence of stem scar mold greatly. The tape presumably prevented recontamination and subsequent infection. Irradiation had no consistent effect on flesh firmness. (MQ 2-82)

5. Onions. In studies conducted in New York in cooperation with the New York Agricultural Experiment Station, dipping freshly harvested inoculated onions in 500 ppm Sorbistat solution decreased decay in storage. After 5 months' storage, treated onions had 18 percent decay while untreated onions had 25 percent decay. Maneb and Botran did not control Botrytis neck rot in storage. After 2 months in storage Downing Yellow Globe variety developed 4.9 percent decay when the plants were spaced in the field 7 per foot compared with 1.2 percent when they were spaced 12 per foot. The closely spaced onions had necks of smaller diameter which were less susceptible to decay. (MQ 2-38)

6. Peppers. Tests at Beltsville showed that the Botrytis fungus readily infected bell peppers through wounds, but pods without wounds were not readily infected. Gray mold infection through wounds occurred at temperatures from 32° through 70° F. with greatest rate of decay on pods held at 70°. Unwounded pods held at high humidity became infected only at temperatures below 50°. Pods held 21 days developed several times as many lesions at 40° as similar pods held at 45°. This indicates that low temperature is the primary predisposing factor of bell peppers to gray mold rot.

In tests at Chicago, actual contact of spores with water films was necessary for infection by Botrytis cinerea. Inoculation of uninjured peppers at recommended storage temperatures (45 - 50° F.) were unsuccessful in absence of a moisture film even when spore germination had occurred. Inoculations of sound peppers by dusting with dry spores were unsuccessful. The presence of wounds or bruises facilitated infection. (MQ 2-52)

A series of five tests was made in Texas to evaluate the effectiveness of different treatments, particularly hot water, for control of bacterial soft rot in inoculated bell peppers. The peppers were held 5 to 7 days at 70° at high relative humidity before final examination. Phytomycin, an antibiotic, very effective in earlier tests, and chlorine, commonly used in commercial treatments, were included in all tests for comparative purposes. Decay control expressed as percentage improvement over the untreated checks was as follows: (1) Phytomycin (100 ppm), 81%; (2) hot water (128° - 1.5 min.), 74%; (3) hot water (123° - 2.5 min.), 73%; (4) hot water (133° - 45 sec.), 56%;

- (5) sec-butylamine (1%), 23%; (6) chlorine (250 ppm), 17%; and (7) sorbic acid (5,000 ppm), 15%.

Hot water treatments resulted in slight to moderate surface pitting on some peppers in two tests. Reducing the exposure periods by 15 seconds nearly eliminated the occurrence of pitting without materially affecting the degree of control.

Hydrocooling increased the number of soft rot infections in 11 out of 12 lots. The increase ranged from 2 to 15 times that in comparable non-hydrocooled lots. (MQ 2-87)

7. Sweetpotatoes. Screening tests at Raleigh, North Carolina indicate that Vancide 51 (sodium salt of dithiocarbamic acid and 2-mercaptobenzothiazole), now recommended for sanitizing grading equipment, will control soft rot and black rot without root discoloration or injury. Preliminary toxicity data, developed by the manufacturer, appear favorable for establishment of a residue tolerance. (MQ 2-73)

In tests at Beltsville, Rhizopus stolonifer produced cellulase during growth in both artificial media and sweetpotatoes. The Rhizopus cellulase had optimum activity at about pH 4.8 and was partially resistant to boiling. The heat-resistant components had the same pH optimum as unheated preparations. Heating at 55° C. for 10 minutes destroyed the polymethylgalacturonase and macerating activity without inactivating the cellulase -- under these conditions no effect was observed on either the respiration or the macroscopic appearance of sweetpotato tissue. The respiration rate of normal sweetpotato tissue decreased in the presence of juice expressed from Rhizopus rotted sweetpotatoes. The effect on respiration was detectable slightly in advance of visible signs of tissue maceration. All attempts to separate a toxic factor from the macerating enzymes were unsuccessful. It is concluded that "killing in advance" of fungal mycelial penetration in the Rhizopus rot of sweetpotatoes is due to the action of the macerating enzymes. (MQ 2-60)

8. Tomatoes. A variation in susceptibility to cold injury was found among tomato varieties grown in Florida and harvested at the mature-green stage. Tomatoes of the W. R. Grothan, Grothan Globe, Homestead, and Marion varieties had less *Alternaria* stem-end decay than those of the Indian River, Manapal, STEP 409, 410, and 430 varieties after 10 days at 50° and 40° F. In addition, tomatoes of the W. R. Grothan, Grothan Globe, Homestead, and Marion varieties ripened more rapidly than the other varieties at 70° F., either with or without a previous 10 day storage period at 55°, 50°, or 40° F. (MQ 2-88)

9. Mode of Action of Bacterial Soft Rot of Vegetables. Previously a mutant strain with reduced ability to cause soft rot of several

vegetables was isolated in the New York Market Pathology Laboratory following ultraviolet light irradiation of the bacterial soft rot organism, Erwinia carotovora. The mutant strain has a slower growth rate and reduced pectolytic enzyme activity in host tissue which explains its reduced virulence. On nutrient agar, with or without tetrazolium, colonies of a virulent parent pathogen could not be distinguished from a weakly virulent mutant strain of Erwinia carotovora. Upon the addition of dextrose, levulose, or saccharose to nutrient agar, the smooth, large-sized colonies of the parent strain could be readily distinguished from the rough, small-sized colonies of the mutant strain. Colonies of the virulent strain on nutrient agar with sugar and tetrazolium were conspicuously redder than colonies of the weakly virulent mutant. Colonies of the two strains were indistinguishable when the nutrient agar was supplemented with pyruvate, citrate, or malate. (MQ 2-3)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Maintenance in Handling and Packaging.

- Kaufman, J., Ceponis, M., and Michelstein, J. 1963. Effects of Chemical Treatment on Quality of Prepackaged Vacuum Cooled Cauliflower. Agricultural Marketing Service Report No. 506. (MQ 2-61)
- Lipton, W. J., and Ceponis, M. J. 1962. Retardation of Senescence and Stimulation of Oxygen Consumption in Head Lettuce Treated with N⁶ Benzyladenine. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 379-384. (MQ 2-58)
- Ringel, S. M., Kaufman, J., Ceponis, M. J., and Langlois, R. W. 1962. Some Quality Changes in Onions During Marketing. Agricultural Marketing Service Report No. 488. (MQ 2-38)
- Stewart, J. K., and Barger, W. R. 1962. Effects of Precooling Method on the Quality of Crate-Packed and Prepackaged Celery. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 347-353. (MQ 2-21)

Quality Maintenance During Transportation.

- Barger, W. R. 1963. Vacuum Precooling -- A Comparison of the Cooling of Different Vegetables. Marketing Research Report No. 600, 12 pp. (MQ 2-80)
- Johnson, Howard B. 1963. Truck-Rail and Sea-Land Shipping Tests with Texas Fruits and Vegetables. Marketing Research Report No. 589. (BS 2-165)
- Moran, C. H., Hardenburg, R. E., Peel, R. D., and Moore, J. F. 1962. Commercial Packaging and Truck Transportation of Bare Root Tomato Plants in Polyethylene-Lined Crates. Proc. Amer. Soc. Hort. Sci., Vol. 81, pp. 458-466. (BS 2-97)

Postharvest Physiology.

- Ryall, A. Lloyd. 1963. Effects of Modified Atmospheres from Liquefied Gases on Fresh Produce. Proc. 17th Nat'l Conf. Handling Perishable Agric. Commodities, pp. 21-24. (MQ 2-71)
- Scholz, E. W., Johnson, H. B., and Buford, W. R. 1963. Heat-Evolution Rates of Some Texas-Grown Fruits and Vegetables. Jour. of the Rio Grande Valley Hort. Soc., Vol. 17, pp. 170-175. (BS 2-141)

Postharvest Disease Control.

Friedman, B. A. 1962. Physiological Differences Between a Virulent and a Weakly Virulent Radiation-Induced Strain of Erwinia Carotovora. Phytopathology, Vol. 52, pp. 328-332. (MQ 2-3)

Friedman, B. A. 1962. Rate of Growth in Host Tissue and Virulence of Erwinia Carotovora. Phytopathology, Vol. 52, p. 732, (Abst.). (MQ 2-3)

Friedman, B. A. 1962. Changes in Virulence of Soft-Rot Bacteria During Laboratory Cultivation and After Ultraviolet Light Irradiation. Phytopathology, Vol. 52, p. 732, (Abst.). (MQ 2-3)

Segall, R. H., and Smoot, John J. 1962. Bacterial Black Spot of Radish. Phytopathology, Vol. 52, pp. 970-973. (MQ 2-64)

Spalding, D. H. 1963. Production of Pectinolytic and Cellulolytic Enzymes by Rhizopus Stolonifer. Phytopathology, Vol. 53, pp. 929-931. (MQ 2-60)

AREA 13

INSECT CONTROL IN MARKETING CHANNELS -- CROSS COMMODITY

Problem.

There are about 100 kinds of stored-product insects that attack agricultural commodities after they are harvested. Fifteen or 20 kinds are extremely abundant and widespread in distribution. Many of the individual kinds feed on a wide variety of raw agricultural commodities and on the products manufactured or processed from them. The associated problems are not usually specific for certain commodities but are more properly considered as cross-commodity problems. The losses caused by stored-product insects in the marketing channels are difficult to assess accurately, but they may be as much as 800 million to 1 billion dollars annually. The actual loss may be in the nature of reduced quality or value because of contamination with insects, or by damage or destruction from their feeding. The insect attack may occur in storage, in the processing plant, in transportation facilities, in retail stores, or even after the product reaches the consumer. There is need for extensive applied research to develop ways of coping with insect problems in the many facets of the marketing channels, some of which have hardly been touched by research. There is also need for a great deal of basic research to provide a sound foundation for conducting applied studies, for properly interpreting the results, and to provide leads to new or improved approaches to prevention and control. The pesticide residue problem is of primary importance in this area of research, and potential residues must be carefully evaluated. There is urgent need for safer, more effective pesticides and improved ways of using them to provide better insect control with the application of smaller amounts of chemicals. Improved insect-resistant packaging and the development of nonchemical control measures would reduce the overall need for pesticides and could even eliminate their use for some specific purposes.

USDA PROGRAM

The Department has a continuing program at Savannah, Georgia, involving entomologists and chemists engaged in basic and developmental studies directed toward the solution of problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with the Entomology Research Division of ARS, the Field Crops and Animal Products Branch of AMS, the Armed

Forces Pest Control Board, the United States Public Health Service, the Food and Drug Administration, the Commodity Credit Corporation, and a number of individual firms and trade associations in the chemical, packaging, paper, synthetic film, food processing, and milling industries. Contributed funds to assist in the program are received from the U. S. Navy, the Commodity Credit Corporation, and firms in the chemical industry.

A contract with the Midwest Research Institute, Kansas City, Missouri, was to facilitate studies being made on repellents for possible use to increase the insect resistance of packages for food, feed, and seed.

A contract with the University of Helsinki in Finland is for the study of postharvest residues of pesticides on agricultural commodities. It became effective in 1960, continues to May 1964, and involves PL 480 funds with a \$56,637 equivalent in finmarks.

A contract with the Central College of Agriculture, Warsaw, Poland, is for a study of the nutritional requirements of mites attacking stored products. It became effective in 1961, continues to February 1966, and involves PL 480 funds with a \$7,326 equivalent in Polish zlotys.

A contract with the Institute of Plant Protection, Poznan, Poland, is for the study of the insect pathogen, Bacillus thuringiensis, as a possible control measure against certain moths attacking stored products. It became effective in 1962, continues to May 1967, and involves PL 480 funds with a \$17,075 equivalent in Polish zlotys.

The Federal scientific effort charged directly to this area of work totals 2.4 professional man-years divided as follows: Nonchemical control 2.1 at Savannah and program leadership 0.3 at Hyattsville, Maryland. Other work at Savannah has direct or indirect bearing on several commodity areas to varying degrees. Most of the progress is reported in Area 13 for the sake of continuity and clarity. The professional man-years have been charged to other areas as follows: 0.8 to Area 2, Dairy Products; 1.3 to Area 3, Deciduous Fruits and Tree Nuts; 6.6 to Area 4, Grain; 1.1 to Area 4a, Rice; 1.0 to Area 6, Oilseeds and Peanuts; 0.8 to Area 8, Wool and Mohair; and 0.5 to Area 11, Tobacco.

Line Project MQ 1-11(C), a study of insect repellents for food, feed, and seed packages, was discontinued with the successful completion of the research contract.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Because most of the work in this area applies equally well to several different commodities, the major part of the manpower for the research has been charged on a proportionate basis to the commodity areas concerned. It is not feasible to report only a portion of the results under the respective areas, or to include all the information under each area. Therefore the entire report is given here and at the end of each major heading the areas are listed in which the information should be of interest.

A. Basic biology, ecology, and physiology.

1. Nutritional Requirements of Mites. Research under a PL 480 project by the Central College of Agriculture in Warsaw, Poland, shows that food requirements of Tyrophagus infestans (Ouds) do not seem to be very specific or very demanding. One of the best diets tested was the so-called "Davis formula" containing 18 amino acids, yeast nucleic acids, starch, cholesterol, mineral salts, and vitamins. On this diet mortality was low, and the time of development was not much longer than on the check diet of yeast or wheat germ. Egg production, however, was only about one-fourth that obtained on wheat germ. The Davis diet enriched with 2 percent of leucine resulted in a shorter developmental period, greater longevity and fecundity, but slightly higher mortality. A diet based on albumin produced the greatest fecundity obtained from any artificial diet yet tested. There was no development at all on diets containing gelatin as the only source of protein. Greater longevity was obtained on diets with large amounts of vitamins. Adults were produced on a number of other diets tested with this species but mortality was usually high and only a few eggs were deposited by the females. (E21-AMS-1(a))

Confirming results during the first year of study, development of Carpoglyphus lactis (L.) on artificial diets continued to be rare. Adult mites were produced on only 6 of 37 diets tested, and on only one was mortality lower than 50 percent. The best diet thus far is the Davis formula enriched with 2 percent of leucine, and second best is the basic Davis mixture. In both cases the developmental period and fecundity were about one-fourth of that obtained when the species was reared on yeast as the check food. Mortality and longevity were about one-half to one-third those from the check diet. (E21-AMS-1(a))

The best artificial diet tested on Acarus siro L. contained 17 amino acids corresponding in ratio to that in gluten. Longevity was about half that on wheat germ the check diet. Good results were also obtained with the Davis formula alone or enriched with 2 percent of leucine. On the other 23 diets tested with this species, longevity was very low even on diets containing 10 percent of vitamins. The time of development on these diets, however, was close to that on wheat germ. (E21-AMS-1(a))

Studies were conducted with all 3 species of mites using food media containing substances that prevent the growth of molds and bacteria. Such organisms can supply mites with additional food components that cannot be identified and that obscure the results from tests with carefully compounded artificial diets. The addition of antimicrobial agents to the food usually inhibited the development of all 3 species, but the species varied in their reaction and the different agents used varied in effect on the mites. The best results were obtained with 0.2 percent of methylparahydroxybenzoate or potassium sorbate, but neither was without some inhibitory effect. No fungi or bacteria were found after mites were reared for 80 days on diets containing either of these compounds. (E21-AMS-1(a))

This information should be of interest in Areas 2, 3, 4, 4a, 6, and 11.

B. Insecticide evaluation.

1. Contact, Residual, and Vapor Evaluations. Of 32 compounds investigated for contact, residue, and vapor toxicity, 24 exhibited one or more of these toxic properties and should be considered for further development for use in the control of stored-product insects. The most promising of the compounds tested for contact toxicity were Bayer 45556, Guthion, Monsanto CP 19203, Shell compounds SD 8280 and SD 8447, and Stauffer B-10046; for residue toxicity, Guthion, Shell compounds SD 8280 and SD 8447, and Stauffer N-2310; and for vapor toxicity, Hercules 3895, Stauffer B-9340, and Virginia-Carolina VC-3-670. Tests in progress indicate that Shell SD 8949 is very promising as a contact insecticide. (MQ 1-23)

In tests conducted to determine the effectiveness of Diazinon emulsifiable concentrates against stored-product insects, Diazinon AG 500 was not significantly more toxic than Diazinon AG 250 to confused flour beetle adults and black carpet beetle larvae; however, it formed more stable emulsions. The Diazinon emulsions were less effective against confused flour beetles than was the malathion emulsion used as a standard. (MQ 1-23)

Papers treated commercially with slow-release lindane and aldrin formulations indicated that extension of the residual life of these insecticides may be obtained with slow-release materials. Tests also were conducted with paper treated at the Savannah, Georgia, laboratory with emulsions containing slow-release malathion formulations in polyvinyl acetate. Emulsions prepared with the 70-percent malathion formulation were more effective against flour beetle adults and black carpet beetle larvae than were those containing technical grade malathion or the 35-percent malathion slow-release material. (MQ 1-23)

In previous tests designed to establish concentration x time factors for adult cigarette beetles, results indicated that the beetle population tested was composed of two groups of unequal susceptibility to DDVP. It appeared that the most susceptible group was predominantly male beetles. Tests were conducted to determine the relative susceptibility of adult male and female beetles to DDVP. After a 2-hour exposure to a vapor concentration of 1.4 micrograms per liter, 97 percent of the males were dead compared with only 14 percent of the females. (MQ 1-24)

Initial tests with black carpet beetle larvae indicated that DDVP was relatively nontoxic to this insect. Only 26 percent of the larvae were dead within 14 days after a 24-hour exposure to a DDVP concentration of 16 micrograms per liter. However, the beetles appeared affected (knockdown or moribund) after exposure to concentrations as low as 3.3 micrograms per liter and the percentage of mortality increased after the standard 14-day post-exposure observation period. To estimate the extent of this delayed mortality action, black carpet beetle larvae were exposed to several DDVP vapor concentrations and mortalities were determined 1, 2, 4, 8, and 16 weeks after exposure. Larval mortality of 81 to 90 percent was attained 16 weeks after 48-, 24-, and 8-hour exposures to vapor concentrations of 2.2, 4.3, and 6.7 micrograms per liter, respectively. (MQ 1-24)

Tests were conducted to determine the susceptibility of fruit flies (Drosophila melanogaster Meig.) to DDVP. The tests were conducted in 1,500-cu. ft. chambers and provided data for estimating mortality x time regression lines for three vapor concentrations. The estimated time required to obtain 95-percent mortality of flies exposed to concentrations of 0.01, 0.05, and 0.14 microgram per liter was 186, 96, and 29 minutes, respectively. (MQ 1-24)

Tests were conducted to determine the effect of cooking on DDVP residues in flour and rice. Bread was prepared, with and without shortening, from flour containing 4.1 p.p.m. of DDVP. Rice, containing 4.9 p.p.m. of DDVP was cooked by stirring it into boiling water and simmering over low heat for 25 minutes. After cooking, DDVP residues in the bread prepared without shortening and in the rice were reduced to only trace amounts. The bread prepared with shortening retained 0.42 p.p.m. of DDVP. (MQ 1-24)

A 6-month test was conducted to determine the effectiveness of semi-monthly aerosol applications of DDVP to prevent insect migration from infested to uninfested bags of flour. The test was conducted in 1,500-cu. ft. chambers using 50-lb. units of flour, packaged in cotton sheeting and multiwall paper bags, stacked to simulate warehouse conditions. The semimonthly DDVP applications greatly suppressed but did not completely prevent migration of insects from infested to uninfested bags of flour. (MQ 1-24)

Design improvements were incorporated into a new model of an apparatus constructed for dispensing insecticides in vapor form. Heated air is forced through a cartridge containing resin pellets impregnated with the insecticide. During 6-hour periods of continuous operation in a 166,650-cu. ft. warehouse, the dispenser gave relatively constant concentrations and uniform distribution of DDVP vapor. The machine is now being used in warehouse tests to determine residues in several kinds of foods with various kinds of packages when weekly applications of DDVP are made. (MQ 1-24)

Tests with DDVP in warehouses are in progress to obtain residue data that will be considered by the Food and Drug Administration with respect to the possible establishment of tolerances in foods. Diversion of effort to MQ 1-24 for developing the background information necessary to conduct the warehouse studies precluded other work in warehouses during most of the reporting period. (MQ 1-25)

2. Fumigant Evaluation. Laboratory space fumigations were conducted to determine dosage-mortality regression lines and LD values for methyl bromide, 1,2,3-tribromopropene, crotyl bromide, and ethyleneimine against adult confused flour beetles, adult saw-toothed grain beetles, adult cigarette beetles, and black carpet beetle larvae. Based on the LD₉₅ values, the candidate fumigants were more toxic than methyl bromide (fumigant standard) to each species, with the exception that methyl bromide was more toxic than crotyl bromide to black carpet beetle larvae. (MQ 1-28)

Preliminary "range finding" space tests were completed for 37 candidate fumigants and 2 experimental fumigant formulations against the previously listed test insects and for N-(alpha-methylacetonitrile)-morpholine formulated with Espesol 5 and with carbon tetrachloride against adult confused flour beetles. Chemicals that showed promise as space fumigants and were tested against adult confused flour beetles in 1-gallon jars containing wheat were as follows: Acrylonitrile, carbon tetrachloride, crotyl bromide, diethylamine, ethyleneimine, Niagara 5961, N-butyl isothiocyanate, Phosdrin, 2-propyn-1-ol, Shell SD 7169, Stauffer N-2790, Substanz 215, Thimet, 1,2,3,-tribromopropene, N-(alpha-methylacetonitrile)-morpholine, and N-(alpha-methylacetonitrile)-morpholine formulated with carbon tetrachloride and Espesol 5. Based on bioassay data, only carbon tetrachloride, N-butyl isothiocyanate, and crotyl bromide effectively penetrated the wheat. Freon and carbon tetrachloride, tested as carriers in forced distribution fumigations, failed to improve the penetration of DDVP, 1,2,3-tribromopropene, or Velsicol W-24 through columns of wheat. (MQ 1-28)

Manpower for the insecticide evaluation work has been charged to Areas 2, 3, 4, 4a, 6, 8, and 11, and the preceding information will be applicable to them.

C. Insecticide residues.

1. Chemical Analysis. Nine different insecticides were represented among the analyses conducted at Savannah, Georgia, during the past year. Samples analyzed involved 26 different agricultural commodities, food products, or packaging components. There was a total of 6,750 samples, an increase of 9 percent over last year, and an all-time high for the project. Air samples to determine DDVP concentration and commodity samples for DDVP residues comprised the major portion of the analytical load. (MQ 1-29)

A satisfactory procedure for preanalysis cleanup of tobacco preparatory to conducting piperonyl butoxide residue analyses was developed and cleanup procedures for the analysis of malathion, lindane, and methoxychlor were investigated. Procedures previously available were inadequate for extracting minute quantities of malathion from raisins and a satisfactory method was developed. (MQ 1-29)

2. Malathion. The fate of malathion residues is the subject of further investigations under a PL 480 project at the University of Helsinki in Finland. There are indications that an enzyme system in plant cells may catalyze the breakdown of malathion residues. It is known that malathion, parathion, or paraoxon inhibit esterase enzymes, therefore an investigation is under way to find whether an application of one of these compounds will retard the disappearance of malathion from a subsequent application. The degradation mechanism of malathion on apples and lettuce is being studied using several different techniques. (E8-AMS-1(a))

The manpower for cross-commodity insecticide residue analysis at Savannah, Georgia, has been charged to Areas 2, 3, 4, 4a, 6, 8, and 11.

D. Nonchemical control.

1. Light Studies. Studies on the effect of light intensity on the response of stored-product insects under controlled conditions were conducted. Black carpet beetle larvae, Attagenus piceus (Oliv.), were exposed to various intensities of 3660 Å black light and to total darkness. In general, the larvae were photonegative, but at certain intensities a reversal in photoresponse occurred. The larvae usually moved more slowly toward than away from the light. In tests conducted with red flour beetle adults, Tribolium castaneum (Herbst.), the majority of the adults responded photopositively. However, preliminary results indicate a difference in their sensitivity to various light intensities. Studies with a suction-type light trap indicated that light intensity is important also in trapping the Indian-meal and tobacco moths. (MQ 1-12)

A modified Reed-type light trap used against the cigarette beetle in tobacco warehouses was tested at various light intensities in a room heavily infested with stored-product insects. Intensity was measured by powerstat settings (volts). An 80-volt setting was most favorable for capturing adults of the Indian-meal moth, tobacco moth, cigarette beetle, and rice weevil. Lesser grain borer adults were captured in highest numbers at 100 volts. Red flour beetles, confused flour beetles, and cadelles were present in the room but were not captured in the trap. (MQ 1-12)

An electroluminescent lamp which emits light peaked at 5100 Å (green) by direct conversion of electrical energy was investigated for its effectiveness in attracting Indian-meal moths. This is a low-wattage lamp which emits no ultraviolet light and produces little heat. When the lamp was placed in a suction-type trap, it was as attractive to the moths as was an argon-glow lamp (ultraviolet). The green lamp also attracted a higher percentage of females than did the ultraviolet lamp. (MQ 1-12)

A trap was designed to catch stored-product insects by means of negative geotropism. The trap was constructed by punching four holes through the sides of a paper drinking cup that was closed with a lid and placing a "skirt" over the holes. Red flour beetle adults readily climbed and entered the trap when no food was present on the outside. When a trap with a lamp in the lid and an unlighted trap were placed on culture media heavily infested with red flour beetle adults, the lighted traps contained 64 percent of the trapped insects. (MQ 1-12)

2. Insect Pathogens. A PL 480 project at the Institute of Plant Protection in Poznan, Poland, is to study the possible use of Bacillus thuringiensis to control the Mediterranean flour moth. The initial experiments were to determine the efficiency of different concentrations in wheat flour of E 58 (a French product containing spores and crystals of B. thuringiensis, strain "Anduze") against young larvae of the flour moth during a 7-day exposure. The LD₅₀ was 0.2 percent, and the LD₉₀₋₉₅ was about 2.0 percent. In other tests the influence of temperature and humidity on the effectiveness of B. thuringiensis was studied. Larvae were exposed to eight different concentrations of the pathogen at temperatures of 15, 20, and 25° C., with a relative humidity of 75 percent. Higher mortality was obtained in the series of cultures maintained at 15° than in those at the higher temperatures, but there was no difference in the effectiveness of the material at 20 and 25° C. There was a straight-line relationship between concentration of pathogen and mortality. Another experiment was conducted at different relative humidities at a temperature of 26° C. No significant differences were found after 21 days in the effectiveness

of the pathogen at the different humidities. These results differ from those of Gibson and Wolf who found that high humidity favored larval resistance to B. thuringiensis, and that the action of the organism in moist atmospheres was weakened. Both factors apparently contributed to a lower mortality at high humidity. Additional experiments were started in an attempt to find an explanation for these conflicting results. (E21-AMS-4(a))

Although the manpower for the nonchemical control studies is charged directly to Area 13, the information reported here will be of interest in Areas 2, 3, 4, 4a, 6, 8, and 11.

E. Insect-resistant packaging.

1. Repellent Evaluation. Of 62 candidate repellents evaluated, only 4 showed sufficient promise to warrant further study. An additional 3 compounds showed promise as adjuvants for pyrethrum to increase the period of its effectiveness as a repellent. Five other compounds were found to extend the duration of repellency of the combination of pyrethrum and piperonyl butoxide. (MQ 1-20)

The contract research by the Midwest Research Institute, Kansas City, Missouri, has been completed in which a critical analysis was made of the experimental data accumulated in the evaluation tests of repellents at Savannah, Georgia. Rather than showing a definite relationship between a single chemical structure, or group of structures, and repellency, the statistical study conducted produced estimates of the probability of discovering the greatest number of effective chemicals on the basis of certain chemical structures and physical properties. It was concluded that the percentage rate of discovery of repellents may be increased considerably by selecting compounds for testing that (1) have 3 or 4 reactive sites, (2) have molecular weights from 151 to 270, and (3) do not have -OH groups. Many repellents lie inside these limitations, and some lie outside. The chance of finding a repellent is much greater if the compound contains an ester, imide, or nitro group. The allyl, amide, and chloro groups also appear to be associated with repellency. Imides were characterized by high initial repellency which was lost at an intermediate rate throughout a 3-month test period. While fewer of the ester, nitro, and amide compounds had very high initial repellency, they tended to sustain this repellency throughout the 3-month test period. Although about 60 percent of the more effective repellents contained a benzene ring, this structure itself did not appear to be directly related to repellency. Certain chemical groups seem definitely to prevent repellency or to keep it from being sustained. This was true most frequently of the -OH groups and to a lesser extent of the ether, amine, and allyloxy groups. (MQ 1-11(C))

The Midwest Research Institute study included statistical analysis of a large quantity of data for the pyrethrum-piperonyl butoxide standard used in the repellency evaluations. The results indicated that piperonyl butoxide did not synergize repellency when mixed with pyrethrum but only gave an additive effect. An evaluation of the repellency test technique used showed that it permits statistical analysis of data and estimates of parameters, but that the efficiency appears to be lower than might be desired, and recommendations were made for revisions of the technique. (MQ 1-11(C))

Based on recommendations in the Midwest Research Institute contract report, a considerable amount of time was spent in making observations, conducting tests, and obtaining data to follow up on these points. Dosage-repellency curves were established for pyrethrum plus piperonyl butoxide, using nine treatment levels for pyrethrins in a 1:10 ratio with piperonyl butoxide. The curves and the R₅₀ and R₉₅ values for each week of testing did not show a uniform rate of repellency loss from one week to the next, indicating other factors than the aging of the papers were also influencing the weekly readings. Tests with insects of four different ages, ranging from 12 to 40 days, showed that age had little effect on the insects' response to the synergized pyrethrum standard. During a 13-week test the repellency of pyrethrum-piperonyl butoxide-treated paper to male and female Tribolium castaneum exposed separately was almost identical but was lower than that obtained when mixed sexes were exposed. No difference could be noted between the repellency response of flour beetle adults that had recovered activity after they had been immobilized for 48 hours on synergized pyrethrum-treated surfaces and the response of adults that had not been exposed to synergized pyrethrum previously. (MQ 1-20)

Detailed observations of the activities of single insects or of insects selected at random from a group of 10 in the exposure arenas showed that some insects moved indiscriminantly over the treated and untreated areas while others stayed in the same position during most of the observation time. Evidence of a thigmotropic response of the insects to the sides of the arena cylinders was noted. (MQ 1-20)

2. Storage Tests. Pyrethrum plus piperonyl butoxide is used at the present time as an insect-repellent treatment on food packaging and is covered by a temporary Food and Drug Administration tolerance effective through June 30, 1964. By that time data must be presented to Food and Drug to show the residue levels that result in various food commodities from the use of these chemicals in coatings on the outer surfaces of packaging. A cooperative test was initiated with the FMC Corporation to determine the rate and extent of the migration of piperonyl butoxide from the treated outer ply of multiwall bags into the packaged commodity when stored under semipractical conditions. After 6 months, residues of piperonyl butoxide in all samples of beans,

rice, and dry milk were below the temporary tolerance of 10 p.p.m. Although residues in flour samples adjacent to the bag walls exceeded the temporary tolerance after 6 months of storage, residues in composited samples did not. (MQ 1-17)

Shipping cases are one of the most difficult types of package to make resistant to insect invasion through physical construction and closure of the container, as demonstrated in past studies. A new test was initiated to compare the resistance to insect invasion of untaped standard shipping cases, untaped cases with shortened slots, and cases with either the center seam or both the center and end seams sealed with synergized pyrethrum-treated tape. Both synergized pyrethrum-treated and untreated cases were included. After 3 months' exposure only the cases with the treated tape on both the center and end seams completely prevented insect invasion. (MQ 1-17)

Storage tests to determine the effectiveness of ENT-1186 (N-phenyl-maleimide) and Sevin (1-naphthyl methylcarbamate) in preventing penetration of kraft packets were completed. The ENT-1186 coating was less effective than the standard synergized pyrethrum coating as all packets coated with ENT-1186 were penetrated within 12 months. Packets coated with Sevin at 50 and 100 milligrams per square foot completely resisted penetration for 18 months. (MQ 1-21)

Storage tests were conducted with kraft packets treated with ENT-31674 (succinimide, N hexyl), ENT-32364 (phthalimide, 3(or 4)-chloro-N-ethyl), ENT-32370 (phthalimide, N-butyl-3(or 4)chloro), ENT-22331 (2,3,5,6,-tetrachlorophenol), ENT-26186 (4-amino-3-nitro-benzotrifluoride), ENT-26188 (5-amino-2-nitrobenzotrifluoride), and ENT-26209 (3-n-butyl-4-ketobenzotriazine). Although these compounds were found to be highly repellent to flour beetles in preliminary laboratory evaluation tests, the treated packets were penetrated in less than 6 months in these semipractical storage tests in a room infested with large numbers of stored-product insects. (MQ 1-21)

Tests on the resistance of 38 flexible packaging materials to insect penetration were completed and tests with an additional 18 materials are still in progress. An 8-mil polyethylene and a 2.7-mil polycarbonate film were not penetrated during a 12-month exposure to insects. One Scotchpak film was not penetrated, and a Reynolds Metals' aluminum foil laminate was highly resistant to penetrations during a 9-month exposure. (MQ 1-22)

Insect invasion tests with multiwall paper bags sealed with the Thermogrip hot-melt tape-over-stitch closure were completed. No insects invaded unpenetrated kraft bags with this closure and exposed intermittently to insects for a total of 6 months during the year subsequent to sealing the bags. "Moistite" bags, a heat-sealed foil-laminated bag developed by Crown-Zellerbach Corporation, were not invaded during a 6-month exposure test. (MQ 1-22)

In research cooperative with The Lord Baltimore Press on shell cartons with "web" and "Van Buren" closures and with synergized pyrethrum added to the adhesive, cut waxed edges, or the overprint varnish, both treated and untreated cartons with the "web" closure were invaded within 1 month. The "Calk-Seal" closure for cartons developed by the Packaging Corporation of America exhibited greater resistance to insect invasion than did the closure used as a standard for comparison. (MQ 1-22)

In preliminary storage tests with small bags, synergized pyrethrum coatings were compared when the base for the coating slurry was silica gel or the standard Celite 209. The coatings were about equal in preventing insect penetration of the bags. These results are of interest because silica gels are also used as antiskid agents on multiwall paper bags. (MQ 1-1)

3. Residue Movement Barriers. Tests to evaluate flexible packaging materials as barriers to the migration of insecticides from coated kraft into packaged commodities showed that two polyvinyl chloride films, two polyethylene terephthalate films, a polyvinylidene-coated cellophane, and a cellulose triacetate film were effective barriers in reducing or preventing contamination of flour by malathion for 1 year. In tests still in progress a polyvinyl fluoride film, greaseproof and bleached glassine papers, and films and coatings of saran (polyvinylidene copolymer) have prevented migration of malathion for at least 4 months. The polyvinyl fluoride film and the films and coatings of saran also appear promising in preventing the migration of piperonyl butoxide or reducing it to levels approaching the sensitivity of the chemical analytical procedure. (MQ 1-1)

The manpower for insect-resistant packaging research has been charged to Areas 2, 3, 4, and 4a, and the preceding information will be applicable to the commodities involved. The information will also be of interest in Area 6.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation.

- Agricultural Marketing Service. 1963. New Insect-Proof Package.
Agricultural Marketing, Vol. 8, No. 4, pp. 4 and 5. April 1963.
(MQ 1-17)
- Soles, Robert L., and Harein, Phillip K. 1962. The Fumigant
Toxicity of Two New Chemicals to Stored-Product Insects. Journal
of Economic Entomology 55(6): 1014-15. (MQ 1-28)
- Stored-Product Insects Branch. 1963. A Portable Recirculation
System for Fumigating Bulk Products in Freight Cars. USDA,
Marketing Bulletin No. 24, 4 pp. (MQ 1)

AREA 14. INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities. This need includes instruments to measure color, moisture content, texture, maturity, composition; and to detect defects in a wide range of commodities. These instruments are needed by inspection and grading services, by food handlers and processors, and by research workers in the broad field of agricultural marketing. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

USDA PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with ARS and other agencies of the Government.

The Federal scientific effort devoted to research in this area totals 5 professional man-years.

REPORT OF PROGRESS AND PUBLICATIONS

A. Objective Measurement and Evaluation of Quality

1. Moisture Measurement. Cooperative work with Joe Hart of the Field Crops and Animal Products Branch has resulted in the development of a new method for measuring moisture content of grain. The spectral absorption characteristics of ground grain were determined with equipment designed and built in our laboratory. These measurements indicated that the water absorption band at 1.94 microns could be measured on ground grain. Techniques were developed for measuring the intensity of this absorption in a reproducible manner and the results were related to moisture content as determined by oven drying. Calibration curves obtained for ground wheat, wheat flour, bran, and soybeans, indicated moisture content could be measured within a standard error of 0.35 percent for samples in the range from 0 to 18 percent moisture.

The infrared absorption measurement offers the possibility of fundamental moisture analysis which is not dependent on oven-drying determinations. Samples of very low moisture content can be measured and the possibility of measurements on individual seeds is being explored.

2. Automatic Data Recording for Cotton Classing. In cooperation with the Cotton Division and the Reports Branch of Administrative Services Division, a device was constructed to simulate the entry of cotton grades and related data on punch cards to be used for electronic processing methods.

This device, CORA (Cotton Recorded Automatically), was used to evaluate the feasibility of automatic recording. Time comparison tests of CORA with conventional classing methods was made by the Cotton Division on 3,000 samples. Without previous experience in operating CORA, six classers examined the cotton samples and determined the quality, color, staple length, and presence of foreign matter. Data were recorded by conventional methods in one test and by operating CORA in a duplicate test. Most of the classers were faster with the conventional method but the differences were small. For the 3,000 samples, CORA classing averaged two seconds per sample more time than the conventional classing procedure. There were no operational difficulties with the machine during these tests.

Plans and designs for a prototype machine to perform all the necessary functions for automatic recording of cotton-classing data were prepared by the Operations Analysis Staff. Technical assistance and advice was given during the preparation of these plans in sufficient detail that they may be used for drafting specifications and performance requirements for a research contract of a prototype system. Further development of this project is the responsibility of the Cotton Division.

3. Fruit and Vegetable Quality Measurements. A test was carried out to determine how well cull apples (apples containing brown tissue) could be separated from sound apples when the fruit are removed from storage, using presently available light transmittance equipment with Δ O.D. (720 - 800 nm) as the index of browning. The results with Delicious and Stayman apples indicated that 90 percent of the apples judged worthless because of internal defects (not traceable to external causes) could be separated from the sound apples, while about 50 percent of the apples judged worthless because of external defects (primarily rots and bruises) could be separated. The corresponding percentages for usable apples were: internal defects 50 percent; external defects 10 percent. The results are in agreement with previous experience wherein internal defects are more likely to be detected because there is less variation in the location of the defects. The detection of small defects is hampered by an interrelationship with chlorophyll in the measurement for defects. In this test, the apples were placed in maturity classes at the start of the test, based on chlorophyll content. However, that method does not appear adequate and a method of measuring and correcting for chlorophyll content has been proposed. Adequate detection of external defects depends on developing a system which would examine separate areas of the fruit to detect small defects.

The results of tests comparing several methods of detecting water core non-destructively in Delicious apples were analyzed and prepared for publication. The various methods were tested on the ability of the technique to separate the sound apples from the severe water core apples. The optical-density difference, O.D. 760 nm - O.D. 810 nm, gave the best results. However, this measurement was related to the fruit temperature. Another factor (K factor = 0.8) was introduced into the measurement to reduce the temperature relation (i.e., O.D. 760 nm - 0.8 O.D. 810 nm). This reduced the temperature effect by two thirds. Fruit size was a factor with nearly all the techniques. Internal browning influenced the light transmittance measurements for water core, but an independent measurement can be made to indicate browning.

Tests were made with cucumbers in an attempt to relate maturity (based on the chlorophyll content as measured with light transmittance) with bloating. The results indicated essentially no relationship. Only the extremely mature cucumbers, showing appreciable yellow color at harvest, showed substantial difference in the severity of bloating; about 90 percent in one test, while the greenest cucumbers had about 20 percent bloaters.

A test was undertaken with onions to determine the feasibility of detecting a physiological defect which appears in onions during storage. The results of this test indicated the defect could be detected if the number of brown scales on the onions could be controlled or measured. The combination of variations in intensity of brown color of the scales and the number of scales caused sufficient variation in the measurement between onions so that only the onions with severe defects could be detected reliably.

The measurement for detection of scald in red tart cherries was reappraised, and new wavelengths were selected for this measurement; i.e., Δ O.D. (730 - 800 nm). This was done to reduce the relationship between the scald index and the color of the cherries. The criterion for the selection of the wavelengths in the new index was based on finding an index that had a minimum variation between sound cherries and a maximum sensitivity to scald.

4. New Instruments. The Interior Quality Fruit Sorter constructed under contract was delivered in a non-operating condition. The main source of difficulty was in the optical design. This was modified and with minor changes in the electronic unit the machine was put into operation. Preliminary tests indicate the machine is adequate for automatic sorting of apples for maturity and internal browning. This unit will be evaluated for a variety of quality evaluation problems and used as a research tool to obtain large quantities of segregated samples.

A simple portable spectroradiometer for the visible and near infrared region has been developed. This instrument uses a wedge-interference filter as the monochromator, a solar cell as the detector, and a battery-powered, transistor voltmeter as the indicator. The unit has been calibrated for wavelength and spectral sensitivity for the 0.4- to 1.2-micron region. It will be particularly useful in measuring the spectral energy

distribution of the various light sources used in our work, including the characterization of light sources used in visual inspection.

A commercial spectrophotometer, the Perkin-Elmer Model 4000, has been modified to permit absorption measurements on dense, light-scattering samples. With this modification the instrument can be used for low-temperature spectroscopy in the ultraviolet, visible and near infrared region. It can also be used for spectral absorption measurements on biological tissues and will be particularly useful for exploring the near infrared region.

Three new filter photometers have been designed and are now being constructed. These instruments will provide measurements at four selected wavelengths rather than two, as in our previous instruments. This will permit rapid analysis of two interior quality factors at the same time. Two of these instruments are designed for the visible region and one for the near infrared. The infrared measuring instrument will be used for indicating moisture content of grain and seeds, and to explore the possibility of measuring other quality factors by infrared transmittance.

B. Biophysics

1. Phytochrome. Our work on phytochrome has continued in cooperation with S. B. Hendricks and H. W. Siegelman of ARS. Spectrophotometric studies of phytochrome denaturation showed that P_R was much more resistant to denaturation than P_{FR} . These results indicated that protein conformation of the two forms is different and thus that the photochemical transformation between the two forms involves a change of protein conformation.

High-speed flash photometry was used to determine the time course for the photochemical conversion. The measurements indicated that transformation of P_R to P_{FR} , following a very brief (10^{-5} sec.) high-intensity flash, took place in two phases: an initial absorbance increase at 730 nm in about 10^{-3} sec. followed by an equal absorbancy increase over about 1 sec. These are very long times for molecular rearrangements and also suggest a change in the protein conformation.

An attempt was made to observe the protein change by optical rotary dispersion spectroscopy, but no change was observed. This measurement would have shown a change in the helical content of the protein, but not necessarily a tertiary change of the conformation. The measurements gave a slight indication of optical activity near 660 nm.

Electron spin resonance spectra were measured to determine if a triplet state, or free radical, were involved in the photoconversion. No indication of either was found. The ESR Spectrum at -196°C . indicated the presence of copper which was in the cupric state in both P_R and P_{FR} . This was conformed by spectrographic analysis.

Action spectra for the photochemical conversion of phytochrome were measured from 300 to 800 nm. The action spectra agreed with measurements of

absorption spectra. The measurements showed that the quantum efficiency of the conversion of P_R to P_{FR} is twice that of P_{FR} to P_R .

Measurements of phytochrome in intact tissue have continued in cooperation with Harry Lane of ARS. The dark conversion of P_{FR} to P_R has been shown to be related in some manner to respiration. Compounds or conditions which inhibit respiration also inhibit the dark conversion.

2. Photosynthesis. Measurements of chlorophyll fluorescence have continued as a part of our investigation of the photochemistry of photosynthesis. The fluorescence yield of chlorophyll in a leaf increases following irradiation with red light and decreases following irradiation with far-red. The action spectrum for the effect of far-red light showed that 705 nm was the most effective wavelength. This indicated that C-705 caused the fluorescence yield of chlorophyll a to decrease. Further action spectra for the effect of red light showed that chlorophyll b and Chl-670 were responsible for the increased yield mediated by red light. The same action spectra have been obtained by others for O_2 evolution in photosynthesis. Chloroplast preparations showed the same light induced fluorescence yield changes that whole leaves showed. The fluorescence yield changes have been closely related to the photochemical action of light in photosynthesis.

PUBLICATIONS

Objective Measurement and Evaluation of Quality

Olsen, Kenneth L., Schomer, Harold A., and Birth, Gerald S. 1962. Detection and Evaluation of Water Core in Apples by Light Transmittance. Wash. State Hort. Assoc. Proc. 58: 195-197.

Biophysics

Butler, Warren L. 1962. Effects of Red and Far-Red Light on the Fluorescence Yield of Chlorophyll In Vivo. Biochim. Biophys. Acta. 64: 309-317.

Butler, W. L. and Norris, K. H. 1963. Lifetime of the Long-Wavelength Chlorophyll Fluorescence. Biochim. Biophys. Acta. 66: (1) 72-77.

Butler, W. L. and Baker, J. E. 1963. Low-Temperature Spectra of Chloroplast Fragments. Biochim. Biophys. Acta. 66: (2) 206-211.

Butler, W. L., Lane, H. C. and Siegelman, H. W. 1963. Non-Photochemical Transformations of Phytochrome In Vivo. Plant Physiology. 38: (5) 514-519.

Butler, Warren L. 1963. Effect of Light Intensity on the Far-Red Inhibition of Chlorophyll a Fluorescence In Vivo. Biochim. Biophys. Acta. 66: (2) 275-276.

Hendricks, Sterling B., Butler, Warren L. and Siegelman, H. W. 1962. A Reversible Photoreaction Regulating Plant Growth. Jour. of Phys. Chem. 66: 2550-2555.

Lane, H. C., Siegelman, H. W., Butler, W. L. and Firer, E. M. 1963. Detection of Phytochrome in Green Plants. Plant Physiology. 38: (4) 414-416.

Olson, R. A., Butler, W. L. and Jennings, W. H. 1962. The Orientation of Chlorophyll Molecules, In Vivo: Further Evidence from Dichroism. Biochim. Biophys. Acta. 58: 144-146.

General

Butler, W. L. and Norris, K. H. 1963. Effects of Light on Plants. Agricultural Engineering. 44: (7) 368-369.

AREA 15. PIONEERING RESEARCH - MARKET QUALITY

Problem. Fresh fruits and vegetables are living organisms that continue many vital processes after harvest. These processes involve biochemical and physiological changes and activities. Rate of ripening, aging and susceptibility to disease are factors greatly influencing the storage and marketing life and the quality of fruits and vegetables. Since fundamental processes in the plant tissues in a large measure govern these changes a continuing need exists for more basic information on postharvest physiology, including enzymatic activities, the biosynthesis and function of various natural occurring volatiles, reactions of mitochondria including the electron transport chain, the cytochromes, and other activities associated with respiration. This information should furnish a basis for a better understanding of the fundamental behavior of agricultural commodities, and result in improved quality in the products that reach the consumer.

USDA PROGRAM

The Department has a continuing program at Beltsville, Maryland, involving plant physiologists and chemists engaged in basic studies directed toward developing information on the physiological and biochemical changes that occur in fruits and vegetables and other plant material after harvest under conditions that may be encountered in transportation, storage and marketing. This work supplements and is cooperative with other marketing research and with ARS and other agencies of the government.

The Federal scientific effort devoted to research in this area totals 3 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Postharvest Physiology

1. Ethylene and Ethylene Oxide. Work has been conducted on the origin and role of ethylene in plant tissues. A relationship between fatty acid decomposition and the production of saturated hydrocarbons, such as ethane, has been shown to occur in systems prepared from plant material. These reactions are believed to be closely associated with the production of unsaturated hydrocarbons such as ethylene. While an enzyme system that produces ethylene has not been isolated, information on ethylene production has been obtained from plant tissues and from the microorganism, *Penicillium digitatum*. Ethylene production was not related to growth of the microorganism. Still cultures produced much more ethylene than cultures shaken continuously although the later produced 3 to 5 times as much growth. Yeast extract very greatly stimulates ethylene production. Iron, zinc, and thiamine added to the nutrient media eventually stimulates ethylene production as much as yeast extract but a lag period of about 7 days is necessary before this becomes evident.

Ethylene oxide is a gas that appears to counteract the aging and ripening effects stimulated by ethylene. It has been found that ethylene oxide causes a reversible inhibition of ripening in tomatoes and plums, retards the opening of cut roses and prevents "sleepiness" in carnations normally induced by ethylene. Ethylene oxide inhibits ethylene production in all tissues tested thus far. The antagonistic effect of ethylene oxide on ethylene provides direct evidence for considering ethylene as a hormone. From 0.2 to 0.4% ethylene oxide in the air surrounding the commodity for a treatment period of 16 to 20 hours was found effective on several commodities tested. Up to 0.75% may be used on tomatoes. Many tissues are very sensitive to injury by ethylene oxide and may require a very narrow concentration range and careful temperature control to obtain beneficial results. Testing of the effect of ethylene oxide on cut flowers was done in cooperation with the Vegetables and Ornamentals Research Branch, ARS.

2. Mitochondria and Cytochromes Studies. Work with mitochondria isolated from sweetpotato roots showed that the antioxidants, butylated hydroxy-anisole and butylated hydroxytoluene, produced a stronger inhibitory effect on the NADH (reduced form of nicotinamide-adenine dinucleotide)-flavoprotein cytochrome couple than on other sites of the electron transport chain. Oxidative phosphorylation was also inhibited.

These antioxidants and diphenylamine have very similar effects on the activities of mitochondria and on the respiration of intact tissues such as potato slices. Studies on fragments of mitochondria produced by sonic oscillation and various solvents confirm earlier findings that mitochondria are made up of repeating units which when separated are able to function in much the same manner as the intact particle.

3. Mode of Action of Diphenylamine, (DPA). An attempt was made to learn more about the mechanism of control of apple scald with DPA which still remains largely unexplained. Earlier work in this laboratory indicated that DPA inhibits the cyanide and antimycin A resistant fraction of succinoxidase activity in sweetpotato mitochondria. Aged washed potato disks develop a type of respiration insensitive to cyanide and antimycin A but very sensitive to DPA. This indicates that DPA exerts a stronger block on the alternate electron transport pathway than on the normal pathway sensitive to the usual classical inhibitors. Several other antioxidants such as butylated hydroxy-anisole and butylated hydroxytoluene affect respiration very similarly to DPA. These results fit a hypothesis that DPA action is related to the formation of a reactive radical plus a hydrogen atom. Not only may these findings indicate a partial explanation of the activity of DPA in preventing apple scald but they also suggest a valuable use of DPA for studying cyanide resistant respiration and the coupled phosphorylative pathway.

4. Respiration of Potatoes After Cold Storage. Potato tubers exhibit three types of respiration: (1) a basal or ground respiration characteristic of sound intact tubers, (2) a stimulated basal respiration caused by chemicals, bruising, heat, cold, wounding, anaerobiosis etc., and (3) an induced respiration characteristic of cut slices of potatoes that develops hours

after the second type of respiration has been observed. The respiratory burst following cold storage is sensitive to cyanide and carbon monoxide which indicates it is mediated by the same terminal oxidase as the basal respiration. Potatoes from 12.8° C storage showed much greater stimulation in respiration when treated with chlorohydrin than similarly treated tubers from storage at 0° C. This indicates that ethylene chlorohydrin and cold storage have similar effects on respiration and that these effects are not additive. Respiration stimulated by wounding was also sensitive to the same inhibitors as the increased respiration caused by ethylene chlorohydrin and cold. The third type of respiration proceeds at a very high rate, is insensitive to cyanide and other inhibitors, and appears to be associated with synthesis and repair of the cut surfaces of the slices.

5. Russet Spotting of Lettuce. The actual browning of the tissues in russet spotting of lettuce must be due to an oxidation reaction. Various anti-oxidants applied to the heads gave extremely variable and inconsistent results ranging from perfect control to no effect with the same chemical in different experiments. Ethylene oxide at concentrations below 0.2% in the atmosphere had no effect and at higher concentrations induced spotting similar to russet spotting.

6. Hematin Compound in Peanuts. A cooperative study is being carried on with the Instrumentation Laboratory on the physiological role of a hematin compound found in germinating peanuts.

PUBLICATIONS

Postharvest Physiology

- Lieberman, Morris and Mapson, L. W. 1962. Inhibition of the Evolution of Ethylene and the Ripening of Fruit by Ethylene Oxide. *Nature* 196. pp. 660-661.
- Lieberman, Morris and Mapson, L. W. 1962. Fatty Acid Control of Ethane Production by Sub-Cellular Particles from Apples and its Possible Relationship to Ethylene Biosynthesis. *Nature* 195. pp. 1016-1017.
- Butler, W. L., and Baker, J. E. 1963. Low-Temperature Spectra of Chloroplast Fragments. *Biochimica et Biophysica Acta* 66. pp. 206-211.
- Asen, Sam and Lieberman, Morris. 1963. Ethylene Oxide Experimentation Aimed at Cut Flower Longevity. *The Florists' Review*, Vol. CXXXI, No. 3398.
- Asen, Sam and Lieberman, Morris. 1963. Ethylene Oxide Found to Combat Deterioration of Carnations. *The Florists' Review*, Vol. CXXXII, No. 3431.
- Baker, J. E. 1963. Inhibition of Cyanide-Resistant Respiration in Potato Disks by Diphenylamine and Other Anti-Oxidants. (Abstract). *Proc. of Annual Meetings, Am. Soc. Plant Physiologists*. p. XX.
- Lieberman, Morris, Kunishi, A. T., and Mapson, L. W. 1963. Characteristics of an Ethane-Producing System from Apple Tissue and its Possible Relationship to the Ethylene Producing System. (Abstract). *Proc. of Annual Meetings, Am. Soc. Plant Physiologists*. p. LIX.
- Spalding, Donald H., and Lieberman, Morris. 1963. Biosynthesis of Ethylene by *Penicillium Digitatum*. (Abstract). *Proc. of Annual Meetings, Am. Soc. Plant Physiologists*. pp. LVIII-LIX.
- Asen, Sam and Lieberman, Morris. 1963. Retardation of Senescence in Cut Roses by Ethylene Oxide. (Abstract). *Sixteenth Annual Meeting, Am. Soc. Hort. Sci.* p. 60.

Line Project Check List -- Reporting Period October 1, 1962 to September 30, 1963

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Summary of Progress	Incl. in Area & Sub-Subheading
MQ 1	Methods for the prevention and control of insects attacking agricultural products in the marketing channels. Program Leadership	Hyattsville, Md.		
MQ 1-1 (R)	Packaging insecticide formulation studies	Savannah, Ga.	Yes	13-E-2,3
MQ 1-3	Fumigating stored mill rice*	Houston, Tex.	Yes	4a-D-2
MQ 1-4	Controlling dermestid beetles in dry milk plants*	Madison, Wis.	Yes	2-B-1,2
MQ 1-5	Drosophila flies affecting dried fruit industry*	Fresno, Calif.	Yes	3-G-2
MQ 1-6	Fumigation studies on cheese mites	Madison, Wis.	Yes	2-B-2
MQ 1-7	Ecology of stored-tobacco insects	Richmond, Va.	Yes	11-A-1
MQ 1-8 (C)	Effects of EDB on egg laying*	Athens, Ga.	Yes	4-C-5
MQ 1-9	Infrared rice dryers for insect control*	Houston, Tex.	Yes	4a-D-4
MQ 1-10	Fumigation of stored tree nuts		No	
MQ 1-11 (C)	Study of insect repellents for packaging*	Kansas City, Mo.	Yes	13-E-1
MQ 1-12	Physical energy for detecting and controlling insects	Savannah, Ga.	Yes	13-D-1
MQ 1-13	Packaging for dry milk	Madison, Wis.	Yes	2-B-4
MQ 1-14	Insect control in farmers stock peanuts*	Tifton, Ga. Savannah, Ga.	Yes	6-C-2
MQ 1-15	Laboratory evaluation of protectants for commodities	Manhattan, Kan. Savannah and Tifton, Ga.	Yes	4-C-2,4 6-C-1
MQ 1-16	Forced-distribution fumigation of grain in commercial storages		No	
MQ 1-17	Storage tests of insect-resistant packages	Savannah, Ga.	Yes	13-E-2
MQ 1-18	Effects of air movement on stored-grain insects	Manhattan, Kan.	Yes	4-C-1
MQ 1-19	Protective treatments for rough rice	Houston, Tex.	Yes	4a-D-4
MQ 1-20 (C)	Preliminary evaluations of compounds for insect-resistant packages	Savannah, Ga.	Yes	13-E-1
MQ 1-21	Preliminary storage tests of insect-resistant package treatments	Savannah, Ga.	Yes	13-E-2
MQ 1-22	Physical resistance of packages to insects	Fresno, Calif Savannah, Ga.	Yes Yes	3-G-4 13-E-2
MQ 1-23	Preliminary evaluation of insecticides	Savannah, Ga.	Yes	13-B-1
MQ 1-24	Development of aerosol and mist spray formulations	Savannah, Ga.	Yes	13-B-1
MQ 1-25	Spray application studies for warehouses	Savannah, Ga.	Yes	13-B-1
MQ 1-26	Laboratory evaluation of mothproofing compounds	Savannah, Ga.	Yes	8-B-1
MQ 1-27	Intermediate evaluation of grain protectants		No	
MQ 1-28	Laboratory evaluation of fumigants for stored-product insects	Savannah, Ga.	Yes	13-B-2
MQ 1-29	Determination of chemical residues	Savannah, Ga.	Yes	13-C-1
MQ 1-30 (C)	Insect damage to stored corn in the Southeast	Auburn, Ala.	Yes	4-C-3
MQ 1-31	Preconditioning stored-product insects to fumigants	Manhattan, Kan.	Yes	4-C-1
MQ 1-32	Studies of natural attractants in dermestids**	Madison, Wis.	Yes	2-B-1
MQ 0-0- 1(CCC)	Treatments and procedures for preventing loss of CCC grain through insect attack	Manhattan, Kan. Watseka, Ill. Savannah, Ga.	Yes	4-C-1,3,4
	*Discontinued during reporting period			
	**Initiated during reporting period			

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Work & Line Project Number	Work and Line Project Titles	During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
MQ 2	Maintaining and improving agricultural product quality in storage, transportation, and handling. Program Leadership	Hyattsville, Md.		
MQ 2-2	Decay and quality of California globe artichokes	Fresno, Calif.	Yes	12-D-1
MQ 2-3	Made of action of bacterial soft rot*	New York, N. Y.	Yes	12-F-9
MQ 2-4	Quality maintenance in blueberries*	Beltsville, Md.	Yes	3-B-4
MQ 2-5	Precut seed potatoes*	Beltsville, Md.	Yes	9-E-1
MQ 2-7(8)	Control of deterioration of rough rice	College Sta. Tex.	Yes	4a-B-1
MQ 2-8	Storage and chipping quality of new potato varieties*		No	
MQ 2-9	Dried fruits in marketing channels*		No	
MQ 2-10	Washing, cooling and draining of poultry*	Beltsville, Md.	Yes	10-B-1,2
MQ 2-11	Russet spotting of lettuce*	Fresno, Calif.	Yes	12-E-1
MQ 2-12	Storage of plums	Fresno, Calif.	Yes	3-C-3
MQ 2-13	Modified atmospheres, containers, transit services on asparagus	Fresno, Calif.	Yes	12-D-2
MQ 2-14	Transportation and marketing Western melons*		No	
MQ 2-15	Cut flowers and ornamentals	Fresno, Calif. Chicago, Ill.	Yes	11b-A-1 11b-B-1 11b-C-1
MQ 2-16	Softening of brined cherries	Wenatchee, Wash.	Yes	3-F-5
MQ 2-17	Effect of varying temperatures on quality*		No	
MQ 2-18	Transportation in mechanical refrigerator cars*		No	
MQ 2-19	Low temperatures on quality of seed potatoes*		No	
MQ 2-20	Strawberry decay control*		No	
MQ 2-21	Leading pattern and icing practices on celery and peas*	Fresno, Calif.	Yes	12-D-3
MQ 2-22	Decay control in Eastern peaches*	Beltsville, Md.	Yes	3-F-2
MQ 2-23	Maintaining quality of vine ripened tomatoes	Fresno, Calif.	Yes	12-D-5
MQ 2-24	Pre-harvest infection of citrus fruit and post-harvest decay	Pomona, Calif.	Yes	1-E-2
MQ 2-25	Maintaining quality of Hawaiian fruits*		No	
MQ 2-26	Biphenyl resistance of Penicillium on citrus decay*	Pomona, Calif.	Yes	1-E-1
MQ 2-27	Maintaining quality of California Citrus in transit*	Pomona, Calif.	Yes	1-C-3
MQ 2-28	Accumulation of biphenyl in citrus and effect on decay*		No	
MQ 2-29	Detection and description of freezing injury		No	
MQ 2-30	Quality maintenance in dry beans	Beltsville, Md.	Yes	12-B-1
MQ 2-31	Chemicals for control of sprouting	Beltsville, Md.	Yes	9-C-5,6
MQ 2-32	Gamma irradiation of Fruits and vegetables	Presque Isle, Me. Chicago, Ill.	Yes	1-E-4
MQ 2-33	Packaging Eastern peaches and nectarines	Beltsville, Md. Ga. and N.C.	Yes	3-B-3
MQ 2-34(5)	Oxidative deterioration in dry corn	Ames, Iowa	Yes	4-B-1
MQ 2-35	Ventilation on quality of Maine potatoes	Presque Isle, Me.	Yes	4b-B-1 9-C-3
MQ 2-36	Improved packaging of mature green tomatoes		No	
MQ 2-37	Black spot of potatoes	Presque Isle, Me.	Yes	9-F-3
MQ 2-38	Quality changes in apples and onions during marketing	New York, N. Y.	Yes	12-F-5
MQ 2-39	Prestorage treatments of potato diseases	Presque Isle, Me.	Yes	9-C-4
MQ 2-40	Storage and shelf life of Persian limes	Miami, Fla.	Yes	1-E-6
MQ 2-41	Maintenance of quality of poultry in S. E. states	Athens, Ga.	Yes	10-B-3,4,5
MQ 2-42	Leading methods and protective services for Maine potatoes		No	
MQ 2-43	Black Leaf speck of cabbage		No	
MQ 2-44	Long term storage of vegetable oils	Washington, D.C.	Yes	6-B-2
MQ 2-45	Modified atmospheres for berries	Beltsville, Md.	Yes	3-F-4,6,7
MQ 2-46	Ripening of mangoes and avocados	Miami, Fla. Beltsville, Md.	Yes	1-A-3 1-B-1
MQ 2-47	Decay of Florida endive, escarole, cabbage, celery	Orlando, Fla.	Yes	12-F-2,3
MQ 2-48	Controlled atmosphere storage of citrus		No	
MQ 2-49	Sulfur dioxide treatment of grapes	Fresno, Calif.	Yes	3-D-3 3-F-3
MQ 2-50	Market quality Southeastern potatoes		No	

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub- Subheading
MQ 2-51	Storage of Florida citrus*		No	
MQ 2-52	Gray mold of peppers	Beltsville, Md. Chicago, Ill.	Yes	12-F-6
MQ 2-53	Precooling and transporting Florida citrus fruits and vegetables	Orlando, Fla.	Yes	1-C-2 12-D-5
MQ 2-54	Tomato fruit tumor (waxy blister)**		No	
MQ 2-55	Transit temperatures - California potatoes	Fresno, Calif.	Yes	9-D-1
MQ 2-56	Physiological breakdown in stored onions	Fresno, Calif.	Yes	12-C-2
MQ 2-57	Controlled atmospheres for Western apples	Wenatchee, Wash. Fresno, Calif.	Yes	3-C-2
MQ 2-58	Market quality Western lettuce	Fresno, Calif.	Yes	12-D-4
MQ 2-59	Market diseases of cucurbits		No	
MQ 2-60	Host-parasite physiology of market diseases	Beltsville, Md.	Yes	12-F-7
MQ 2-61	Antioxidants, metabolic inhibitors on vegetables	New York, N. Y. Beltsville, Md.	Yes	12-B-2,4,5
MQ 2-62	Deterioration of grass seed	Beltsville, Md.	Yes	4b-B-2
MQ 2-63	Plastic film for Eastern fruit	Beltsville, Md. Wenatchee, Wash.	Yes	3-B-1,2, 3-C-1
MQ 2-64	New market diseases	New York, N. Y.	Yes	9-F-2,4 12-B-3
MQ 2-65	Post-harvest diseases Florida citrus	Chicago, Ill. Orlando, Fla.	Yes	12-F-1 1-E-3
MQ 2-66	Control of pear scald	Corvallis, Ore.	Yes	3-E-3
MQ 2-67	Forecasting storage diseases of apples**	Wenatchee, Wash.	Yes	3-F-1
MQ 2-68	Anthracoise of avocado and mango fruits	Miami, Fla. Orlando, Fla.	Yes	1-E-5
MQ 2-69	Influence of storage temperature on processing quality of potatoes	East Grand Forks, Minn.	Yes	9-C-1,2
MQ 2-71	High nitrogen or carbon dioxide during simulated transit of fruits and vegetables**	Beltsville, Md.	Yes	1-C-4 3-D-5 12-E-2
MQ 2-72	Lenticel spot of Golden Delicious apples**	Wenatchee, Wash.	Yes	3-E-4
MQ 2-73	Reducing injury, decay, and shrinkage of sweetpotatoes**	Raleigh, N. C.	Yes	12-B-6 12-C-3 12-F-7
MQ 2-74	Reducing spoilage and improve quality of Florida grapefruit on European markets**	Orlando, Fla.	Yes	1-C-1
MQ 2-75	Development of improved methods for maintaining meat quality in market channels**	Beltsville, Md.	Yes	5-B-1
MQ 2-76	Cause and prevention of heat damage in rough rice**	College Sta. Tex. La. and Ark.	Yes	4a-C-1
MQ 2-77	Cause and prevention of damage and off color in rough rice**	College Sta. Tex. La. and Ark.	Yes	4a-C-2
MQ 2-78	Reduction of bruising of Red River Valley Potatoes during handling into storage**	East Grand Forks, Minn.	Yes	9-B-1
MQ 2-79	Respiration of citrus fruit in relation to rind breakdown**	Orlando, Fla.	Yes	1-D-1
MQ 2-80	Vacuum cooling pre-packaged vegetables**	Fresno, Calif.	Yes	12-B-7
MQ 2-81	Quality retention of eviscerated poultry**	Beltsville, Md.	Yes	10-B-6
MQ 2-82	Gamma radiation on market life of fruits and vegetables**	Fresno, Calif.	Yes	3-F-9 12-F-4 3-D-2,5
MQ 2-83	Transit environments on Western strawberries**	Fresno, Calif.	Yes	3-D-1
MQ 2-84	Transit refrigeration of Western fruits and vegetables in mechanically refrigerated cars and trailers**	Fresno, Calif.	Yes	
MQ 2-87	Control of bacterial soft rot in bell peppers**	Harlingen, Tex.	Yes	12-F-6
MQ 2-88	Ripening of Florida-grown tomatoes**	Orlando, Fla.	Yes	12-F-8
MQ 2-89	Storage of asparagus crowns**	Beltsville, Md.	Yes	12-C-1
MQ 2-91	Apple scald**	Beltsville, Md.	Yes	3-E-1
MQ 0-0- 2(COC)	Corn deterioration in storage	Watseka, Ill.	Yes	4-B-2
MQ P-1	Pioneering Research Post Harvest Physiology	Beltsville, Md.	Yes	3-E-1 11b-D-1 12-E-1

*Discontinued during reporting period

**Initiated during reporting period

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
MQ 3	Basic research on quality evaluation and development of objective measurement of quality factors in agricultural products. Program Leadership	Hyattsville, Md.		
MQ 3-1(C)	Development of a small scale spinning test	Washington, D.C.	Yes	7-A-1
MQ 3-3(C)	Quality indicators for stored wheat	Clemson, S. C.		
MQ 3-4	Rapid determination of length and length distribution of cotton fiber*	Kansas City, Mo.	Yes	4-A-1
MQ 3-5	Rapid measurement of oil and moisture content of cotton seed*	Beltsville, Md.	Yes	7-A-6
MQ 3-6	Elastic energy as a means of indicating spinning potential of cotton*	Clemson, S. C.	Yes	7-A-6
MQ 3-7	Integration of measurements for oil content and quality of cotton seed oil*	College Sta. Tex.	Yes	7-B-1
MQ 3-8(C)	Seed blending methods for commercial seed lots*	Washington, D.C.	Yes	7-B-2
MQ 3-9(C)	Study of the factors influencing quality in pork*	Beltsville, Md.	Yes	4b-A-1
MQ 3-10	The influence of bovine age upon the characteristics of meat and carcass grade*	State Col. Miss.	Yes	5-A-1
MQ 3-11	Simplified screening tests for chlorinated hydrocarbon pesticide residues in dairy products	Beltsville, Md.	Yes	5-A-2
MQ 3-12	Identification of rice varieties	Beltsville, Md.	Yes	2-A-1
MQ 3-13	Relation of spinning performance of cotton to color grade (C)	Beltsville, Md.	Yes	4a-A-1
MQ 3-14	Quick dye methods for determination of protein content of milk (C)	Lubbock, Tex.	Yes	7-A-2
MQ 3-15	Evaluating quality of tomatoes for processing	Davis, Calif.	Yes	2-A-2
MQ 3-16	Objective measurements for determining the degree of milling of rice	Beltsville, Md.	Yes	12-A-2
MQ 3-17	Relation of cotton fiber measures and properties to yarn strength and appearance	College Sta. Tex.	Yes	4a-A-2
MQ 3-18	Quick test for detection of damage by heat in artificially dried corn	Washington, D.C.	Yes	7-A-3
MQ 3-19	Classification of seedlings of southern crop seeds*	Raleigh, N. C.	Yes	4-A-2
MQ 3-20	Seasonal changes and metabolic activity of oranges (C)	Beltsville, Md.	Yes	4b-A-2
MQ 3-21	Mechanization of seed purity analysis (C)	Orlando, Fla.	Yes	1-A-1
MQ 3-22	Disease syndromes of market poultry (C)	Riverside, Calif.		
MQ 3-23	Determination of moisture in grain, seeds, and oilseeds	Beltsville, Md.	Yes	4b-A-3
MQ 3-24	Equipment for sampling and grading small grains and soybeans	Beltsville, Md.	Yes	4b-A-4
MQ 3-25	Oil quality changes in long term storage	Corvallis, Ore.	Yes	4b-A-3
MQ 3-26	Defect evaluation of peanuts (C)	Davis Calif.	Yes	10-A-1
MQ 3-27	Quality measurement of red tart cherries	Beltsville, Md.	Yes	4-A-3
MQ 3-28	Quality measurement of apples	Beltsville, Md.	Yes	4-A-4
MQ 3-29	Methods and equipment for grading farmers' stock peanuts	Washington, D.C.	Yes	6-B-3
MQ 3-30	Lighting system for grain inspection	Beltsville, Md.	Yes	6-A-2
MQ 3-31	Assessing the sanitary quality of commercial egg solids	College Sta. Tex.	Yes	3-A-3
MQ 3-32	Seed metabolism	Penn. & Mich.	Yes	3-A-3
MQ 3-33	Effects of various production, harvesting and ginning practices on spinning performance and cotton quality (C)	Beltsville, Md.	Yes	3-A-1,2
		Wenatchee, Wash.	Yes	6-A-1
		Raleigh, N.C.	Yes	4-A-5
		Beltsville, Md.	Yes	10-A-2
		Beltsville, Md.	Yes	4b-A-5
		Clemson, S.C.	Yes	7-A-4,5

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in Summary of Progress		Area & Sub-Subheading
MQ 3-34 (C)	Evaluating market quality of livestock and meat	Beltsville, Md.	Yes		4-B-1 5-A-3,4
MQ 3-36	Measurement of flour yielding capacity of wheat	Beltsville, Md.	Yes		4-A-6
MQ 3-37	Measuring character factors in canned southern peas*		No		
MQ 3-38	Maturity determinations in Italian prunes		No		
MQ 3-39	Evaluation and development of physical techniques for determining the purity of certain grass seeds**	College Sta. Tex.	Yes		4b-A-6
MQ 3-40	Determining susceptibility of potatoes to bruising**	E. Grand Forks, Minn.	Yes		9-A-1
MQ 3-41	Development of accurate and rapid method for determining the moisture content of grass and legume hay**	Beltsville, Md. College Sta. Tex.	Yes		4b-A-7
MQ 3-42	Investigations of surface contamination on cotton fibers**	Clemson, S.C.	Yes		7-A-8
MQ 3-43	Methods of measuring the frictional properties of cotton fibers**	Clemson, S.C.	Yes		7-A-9
MQ 3-44 (C)	A study of methods for grading milk**	St. Paul, Minn.	Yes		2-A-3
MQ 3-45	Evaluation of equipment and method for the rapid measurement of the refining loss of cottonseed oil**	Washington, D.C.	Yes		7-B-3
MQ 3-46	Aromatic polynuclear hydrocarbons in or on citrus fruit**	Pomona, Calif.	Yes		1-A-2
MQ 3-47	Evaluation of cotton fiber testing instruments for measuring cotton fiber quality characteristics**	Clemson, S.C.	Yes		7-A-10
MQ 3-48	Development of an automatic alternating temperature seed germinator for use in routine testing**	College Sta. Tex.	Yes		4b-A-8
MQ 3-50	Fresh product factors to processed quality in sweet-potatoes**	Beltsville, Md.	Yes		12-A-1
MQ 0-0- 2(CCC)	Corn deterioration in storage (Formerly MQ 3-70)	Watseka, Ill.	Yes		4-B-2
*Discontinued during reporting period					
**Initiated during reporting period					

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in Summary Area & of Sub- Progress Subheading	
	Foreign Agricultural Research Projects Under Section 104(a) of Public Law 480. Projects sponsored by Agricultural Marketing Service			
A7-AMS-6	Post-harvest diseases of tropical and subtropical fruits	Allahabad, India	Yes	1-E-7
A7-AMS-12	Studies in the "canary coloration" of raw wools	Delhi, India	Yes	8-A-1
A10-AMS-4	Effect of ethylene dibromide on animals	Rehovot, Israel	Yes	4-C-5
A10-AMS-7	Development of a rapid, simple test for protein nutritive value of cereal grains and feeds	Haifa, Israel	Yes	4b-A-9
A10-AMS-11	Influence of environmental factors on population dynamics of khapra beetle	Jerusalem, Israel	Yes	4-C-1
A22-AMS-1	Development of an odor-measuring instrument for use in inspection and grading of foods	Istanbul, Turkey	Yes	5-A-5
E8-AMS-1	Studies of pesticide residues	Helsinki, Finland	Yes	3-F-10 13-C-2
E8-AMS-2	Contamination and deterioration of market milk by non-pathogenic bacteria	Helsinki, Finland	Yes	2-A-4
E8-AMS-5	Effect of atmospheres with various concentrations of added carbon dioxide or nitrogen upon the properties of refrigerated meat	Hameenlinna, Finland	Yes	5-C-1
E9-AMS-4	Relationship between cotton fiber maturity and breakage during mechanical processing to processing performance and product quality	Rouen, France	Yes	7-A-11
E9-AMS-5	Instrument for homogenizing and orienting fibers in samples for cotton testing	Rouen, France	Yes	7-A-12
E16-AMS-4	X-ray research applied to fruit pathology	Palermo, Italy	Yes	1-E-8
E15-AMS-8	Persistence and fate of pesticide residues in wheat	Rome, Italy	Yes	4-C-6
E15-AMS-9	Insect infestation in spaghetti, macaroni, and noodles	Rome, Italy	Yes	4-C-4
E15-AMS-12	Effect of long-term storage upon quality of edible vegetable oils	Garoglio, Italy	Yes	6-B-4
E19-AMS-8	Influence of fiber length distribution on yarn quality mill processing performance	Delft, Netherlands	Yes	7-A-13
E19-AMS-11	Health condition of seeds in commercial channels. Development of methods suitable for routine testing of seed for seed-borne organisms	Wageningen, Netherlands	Yes	4b-A-11
E21-AMS-1	Nutritional requirements of mites	Warsaw, Poland	Yes	13-A-1
E21-AMS-4	Biological control of grain moths	Poznan, Poland	Yes	13-D-2
E21-AMS-6	Influence of storage changes in flaxseed on quality of seed and properties of linseed oil	Olsztyn, Poland	Yes	6-B-1
E21-AMS-7	Effect of microflora of wheat flour on its stability, biochemical and technological properties	Poznan, Poland	Yes	4-B-3
E25-AMS-1	Development of objective methods for measuring market quality of raw and precooked rice	Valencia, Spain	Yes	4a-A-3
E25-AMS-5	Relation of changes in the chemical and biological properties of lysozyme to changes in quality of shell eggs held in cold storage	Madrid, Spain	Yes	10-B-7
E25-AMS-6	The detection of additives in citrus juice **		No	
E29-AMS-1	Apple respiration in modified atmospheres	Kent, England	Yes	3-E-2
S3-AMS-2	Substrate moisture levels for germination testing of agricultural seeds	Sao Paulo, Brazil	Yes	4b-A-10
S5-AMS-3	Chemical and physiological variables of avocados and papayas	Bogota, Colombia	Yes	1-D-2
S9-AMS-6	Underground storage of corn in airtight silos	Montevideo, Uruguay	Yes	4-B-4